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TECHDATA: A COMPENDIUM

Larry Testerman

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139 Barnes Drive, Suite 2
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April 1994

Final Technical Report for Period November 1990 - November 1993

Approved for public release; distribution unlimited.

AIR FORCE MATERIEL COMMAND
TYNDALL AIR FORCE BASE, FLORIDA 32403-5323

ARMSTRONG LABORATORY

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This report has been reviewed and is approved for publication,

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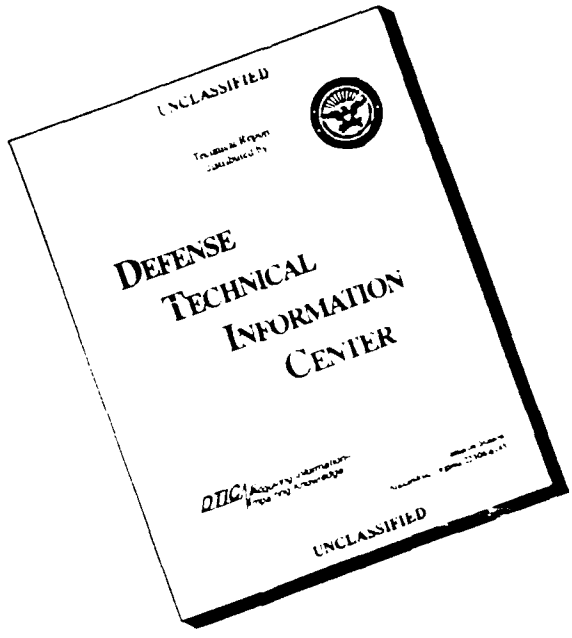

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This technical report provides the reader with a compendium of TECHDATA published by the Air Force Engineering and Services Laboratory, Air Force Civil Engineering Laboratory, and Armstrong Laboratory Environics Directorate from November 1990 to the Present. It provides technical descriptions of technologies or processes developed by this organization as it went through several major reorganizations or force realignment. It refers the reader to documents and contacts who can provide more information about the research and development efforts depicted. It covers a wide range of environmental quality and civil engineering research. Areas addressed include: commercial technology exploitation, rapid runway repair, pavements, energy, structure, airbase survivability, protective construction design, fire protection and crash rescue, environmental compliance and site remediation. Readers can use this report as a point of reference to the technologies described in TECHDATA.

14. SUBJECT TERMS TECHDATA, Commercial Technology Exploitation, Folded Fiberglass Mats, Rut-Resistant Asphalt, JP-8 Use, Airbase Energy Assessment, Geotechnical Centrifuge, Halon Replacement, Hazardous Waste Mimimization, Ion Vapor Deposition, NoX Removal (CONT)

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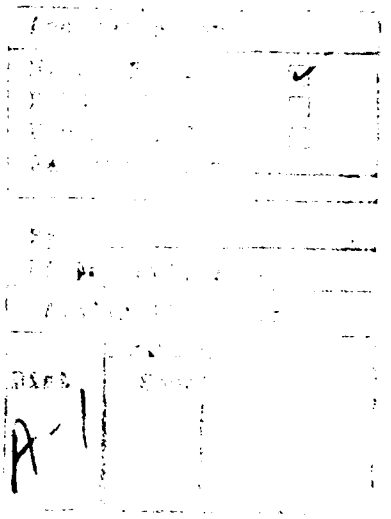
Airbase Survivability, Protective Construction Design, Shock Mitigation, SAFECOMP, Magnesium Fires, Firefighter Training Simulator, Underground Storage Tanks, VOC Monitor, MAILS, Radio-Frequency Heating, In Situ Soil Decontamination, Rotary Air Stripping, Soil Venting, Air Stripper Design, Groundwater Transport Database.

PREFACE

This technical report provides a compendium of previously published research, development, and acquistion TECHDATA to be used as a single-source reference document. It includes the TECHDATA published when this directorate was the Air Force Civil Engineering Laboratory under the Air Force Engineering Services Center (AFESC) and the Air Force Civil Engineering Support Agency (AFCESA), between November 1990 and and June 1993. Because all of these represent research, acquisition, and development, they should be of particular interest to the worldwide scientific and engineering community.

For the convenience of the reader, an updated list of of key contacts within the laboratory structure is included. This should be particularly helpful since some of the contacts listed on the original TECHDATA are no longer here.

Your comments on TECHDATA are always welcome as we seek to make our laboratory products more responsive to our present and potential customers.



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SECTION I

INTRODUCTION

A. OBJECTIVE

The purpose of this technical report is to provide our customers with a compendium of TECHDATA sheets published by our laboratory since the inception of the TECHDATA program in 1990. This should provide a handy single-source reference document to all that have been published.

B. BACKGROUND

TECHDATA, as authorized by AFR 8-16, evolved from AFESC's need to better communicate with our customers - civil and environmental engineers at all levels and the worldwide scientific and engineering community, as well as the Major Air Commands that we serve. Although we produce prolific amounts of technical information each year, not all of this information is of immediate interest to all users. A major function of TECHDATA is to apprise users of new technologies, processes and procedures, or even of new uses for off-the-shelf technologies and processes.

The format chosen was a short user-oriented description of the technology, summarizing the technology or process and its use, application and benefit. In addition, TECHDATA provides the reader with references to published technical reports and a point of contact at the agency or laboratory. At the date of this report, 28 TECHDATA have been published and our distribution list has grown to over 250 recipients. Although AFR 8-16 was written and approved as a communicative conduit between the AFESC (now AFCESA) and its customers, All TECHDATA published thus far have originated with the research, development, and acquisition arm of the agency.

C. SCOPE

This technical report covers all the TECHDATA published when this laboratory was part of AFCESA, through July 1993. The next report will be published in 1994 and will reflect only environmental quality technologies produced by AL/EQ.

The material contained within this report is organized according to the laboratory thrust or area of interest. The changing office symbols reflect reorganizations that have taken place within the past 2 years.

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SECTION II

TECHDATA BY CATEGORY

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PROGRAMS AND PLANS

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

AF TECHDATA

RDX 90-1 **November 1990**

SYNOPSIS

Air Force Regulation 8-16 established *TECHDATA* as an informational conduit between the Air Force Engineering and Services Center and users of technologies, systems, policies and procedures developed as part of the AFESC effort to improve the quality of life for the line of the Air Force. It facilitates technology transition, technology transfer, functional management, policy, and advocacy in such diverse areas as:

- Energy
- Heating, ventilating, and air-conditioning
- Corrosion control
- Pavements
- Rapid runway repair
- Water treatment and conditioning
- Crash, fire and rescue
- Tools and equipment
- Hazardous materials and processes abatement in workplace
- Environics research and development
- Survivable structures and materials
- Mortuary affairs
- Deployment technology
- Airbase operability training
- Food services technology
- Information management technology
- Construction cost management
- Privatization
- Doctrine
- Specialized research

TECHDATA is one more way that we can keep you informed of what we have done, how our work can be applied; who can benefit; and how the process, system, or technology can be obtained. In addition, we will provide you with the office symbol and telephone number of a technology contact who will be able to answer questions or give you more information.

FREQUENCY

There will be no routine schedule for publishing *TECHDATA*; instead, the will be issued as the need arises

TECHNOLOGY TRANSFER AND TRANSITION

The technologies described in the laboratory *TECHDATA* will either be complete or nearly complete. In some cases, the technology described will be the result of a planned transition through the research and development process for delivery to a Systems Acquisition agency or to a Major Air Command. In other cases, the only deliverable that results from the research may be a technical report. Some of our products may also be eligible for transfer to other government laboratories or to the private sector, under the Technology Transfer Act of 1986. In still other cases, we may be describing an off-the-shelf technology that we obtained from someone else and tested and modified for our use. The latter instance, although providing a valuable service, is neither technology transition nor technology transfer.

INDEXING AND FILING OF TECHDATA

An alphanumeric system is used for each dated *TECHDATA* sheet. The designation is by Directorate or Office and Division responsible for that functional area; for example, RDC 90-1 would indicate the first *TECHDATA* published in 1990 by the Engineering and Services Laboratory's Engineering Research Division. A suggested way of filing the *TECHDATA* for each year would be in a binder, indexed by our alphanumeric designation.

DISTRIBUTION OF TECHDATA

Initial distribution of *TECHDATA* will be to all MAJCOM DEs, AFIT, and applicable Training Centers. Other agencies and individuals will be added, depending on the functional area and the nature and usability of the information included.

OBTAINING TECHNICAL DOCUMENTS

Technical documents listed in the "Documentation" section of *TECHDATA* can be obtained by having your librarian contact either the Defense Technical Information Center (DTIC) or the National Technical Information Center (NTIS), either of which will provide you with a microfiche or hard copy at a nominal fee. If you are a present DTIC user or qualified to become a DTIC user, the cost will be less. Also, if the report is classifed or if its distribution is limited, it can only be obtained through DTIC. Addresses and Telephone numbers are listed below:

DTIC

Defense Technical Information Center, Building 5, Cameron Station, Alexandria VA 22304-6145, (202) 274-6434, DSN 523-6259.

NTIS

National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161-0001, (703) 487-4770 DSN 284-6434.

FEEDBACK

Since *TECHDATA* is a new service, we welcome your comments on its effectiveness. Please call the OPR listed below with your suggestions.

TECHDATA OPR

Larry Testerman, HQ AFESC/RDXI Tyndall AFB, FL 32403, DSN 523-6_59.

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA SHEET

ON-LINE ACCESS TO E&S INFORMATION

RDX 90-2 **November 1990**

SYNOPSIS:

AFESC's Technical Information Center (TIC) is now able to provide Engineering and Services (E&S) personnel, assigned to airbases worldwide, with on-line access to over 24,000 bibliographic records related to E&S mission.

A procedure has been established that will permit communication to and from airbase a major command computers and the TIC TECHLIB database, using the Defense Data Network (DDN) system.

Once access is attained, E&S people can remotely search and retrieve bibliographic records related to their needs.

Environmental Data

The Environics Division has created a special database for environmental quality (EQ) information. After entering the EQ database, customers will be able to search and retrieve bibliographic references which contain abstracts of recent documents related to site remediation and hazardous waste reduction/ minimization. Customers also will be able to request copies of journal articles and/or technical reports listed in the EQ data base. Expansion of this electronic ordering service will depend on customer participation and feedback indicating specific needs.

APPLICATIONS:

This service is now available to all Air Force engineering and services organizations who need technical information related to engineering and services or environmental quality.

BENEFITS:

To support research requirements encountered by base-level people every day, hours of effort, normally devoted to researching and obtaining reference materials, may be saved by using the service. Full use of this service represents a more cost-effective approach to the Engineering and Services mission.

AVAILABILITY:

To obtain the bibliographic data, follow the attached procedures.

TECHNICAL CONTACTS:

Virginia Davis
HQ AFESC/RDXT
Tyndall AFB, FL 32403
DSN 523-6270

Capt. Edward Marchand
HQ AFESC/RDVW
Tyndall AFB, FL 32403
DSN 523-6023

Customer uses EQ database, using Wang terminal for access.

E&S TechData sheets are products of HQ AFESC/RDXI, Tyndall AFB, Fla., 32403-6001.

DDN/WANG Library Database Connection Instructions

1. These instructions outline the procedures to obtain computer access to the Technical Information Center (TIC) of the Air Force Engineering and Services Center, Tyndall AFB, Fla.

2. The first step is to ensure that you have access to the Defense Data Network (DDN). The next step is to ensure that our computer system, ESCSI1, is in your computer directory and your system is in our directory. (If you need to add a name to our directory, contact Lois Alexander (DSN 523-6116).) To logon, use the following: Userid [5] LIB; Password [5] LIBRARY; System [5] ESCSI1. The logon brings you directly to the menu-driven database manager. At the main menu, you can search several different fields. To search the Environmental Quality (EQ) data base, a special subset of the TIC database, select the keyword option. When asked what keyword to look for, use one of the following:

Groundwater (one word)
Hazardous Waste
Industrial Waste
Waste Water Treatment
Industrial Hygiene
EPA (this has relevant items from the Department of the Environment).

After going through the prompts, the program will show you an index of the documents that match the search criteria. You can then look at the complete bibliographical reference. Only the EQ documents have abstracts. If you find an EQ database document you want, you can request it through the TIC by going through the print procedure. NOTE: Printing a document means requesting the document. At the end of the session, the computer will ask for your name and mailing address. At this point, the computer will give your name, address, and any requests that you have made directly to the TIC. Turnaround time is about 2 weeks (unless the document is out).

3. The following is a step-by-step example of how to use the system.

a. Check to ensure you have a DDN connection.

b. Ensure that your system is in our directory and that our system, ESCSI1, is in your directory. Your systems operator should be able to handle it. (To get a system added to our directory, please contact Ms Alexander).

c. Run your local program to do a remote logon sequence.

d. To logon, use the following : Userid [5] LIB; Password [5] LIBRARY; System [5] ESCSI1.

e. Logon profile will bring you to the welcome screen. Press ENTER.

f. At the main menu press Ky and press ENTER.

g. For this example, enter Groundwater, one of the special EQ keywords; the others are Hazardous Waste; EPA; Industrial Waste; Wastewater Treatment, and Industrial Hygiene. Press ENTER.

h. Enter *RDVW* to search the EQ database.

i. Since the database had more than 10 documents that matched your search criteria, the system asks if you want to cut down your search by looking at certain years of publication. If your search consists of more than 50 items, you must limit your search.

j. Enter *N* and press RETURN.

k. Press ENTER and wait for computer to formulate your requests.

l. Press ENTER to see the next screen of the index.

m. Press *d* to see the first screen again.

n. Choose those documents you wish to see. In this case, we will look at No. 2, so enter *2* and press ENTER.

o. By pressing *d*, we can look at the detailed listing of the document. Only those documents in the EQ database have abstracts. These abstracts are part of this detailed listing. Press *d* and ENTER.

p. In this report phase of the program, the screen is a continuous scroll showing only part of the display. Press ENTER for the next screen. To read the rest of the abstract, press ENTER.

q. From here, there are several options. Returning to the multiple display, shows the brief display again and the next item (in this case, it would be number 3). By exiting the report mode, other options may be chosen by entering an *x*, . which lets you leave the database, enter a new search, or print one or more of the records displayed. For this example, we will go to the other options. Enter *x* and press ENTER.

r. To get a copy of anything in that search, you should go into the print mode. Enter *p* and press ENTER.

s. For this example, we only need item 2. Enter *N* and press ENTER.

t. Enter *2* and press ENTER.

u. The computer holds the document information in a temporary memory until the session is completed. Press ENTER to continue.

v. The "other options" menu, permits access to the index just viewed, or the main menu. For example, at the main menu, press ENTER.

w. From the main menu, create another search, or exit the program, pressing ENTER.

x. At "good-bye," press ENTER.

y. The computer now wants to know who gets the information. Type *Test:RDVW*. (If you really wanted item 2, you could enter your own address, separating each line with a colon. TIC will send you a copy.) Press ENTER.

z. Type *Yes* and press ENTER.

aa. Order number, used by TIC, can be ignored. Press ENTER to exit.

bb. The computer disconnects from the network automatically.

4. The Engineering and Services Center will continue to update this system. Documents that you find helpful may be added to our data base for all to benefit.

Contact

Ms Alexander

Andrew Poulis, Chief, TIC, DSN 523-6285

Capt. Ed Marchand, Technical Director/EQ Data base DSN 523-6023

(E-mail address for Capt Marchand is MARCHAND[9]AFESC1.AF.MIL)

5. Additions:

- Full texts of certain documents
- "Site Restoration" as an EQ database keyword for our Technology Data Sheets (TDS). These describe remediation technologies such as costs, performance, how and where the technology works, and factors to consider when using the technology in the field. A prototype is in the system.

Use the above instructions; instead of looking at number 2, look for the title "Site Remediation Technology Data Sheet." Enter that number.

Please give us your feedback.

ACQUISITION TECHNOLOGY

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

COMMERCIAL TECHNOLOGY EXPLOITATION (CTE) PROGRAM

RAA 91-1 **December 1991**

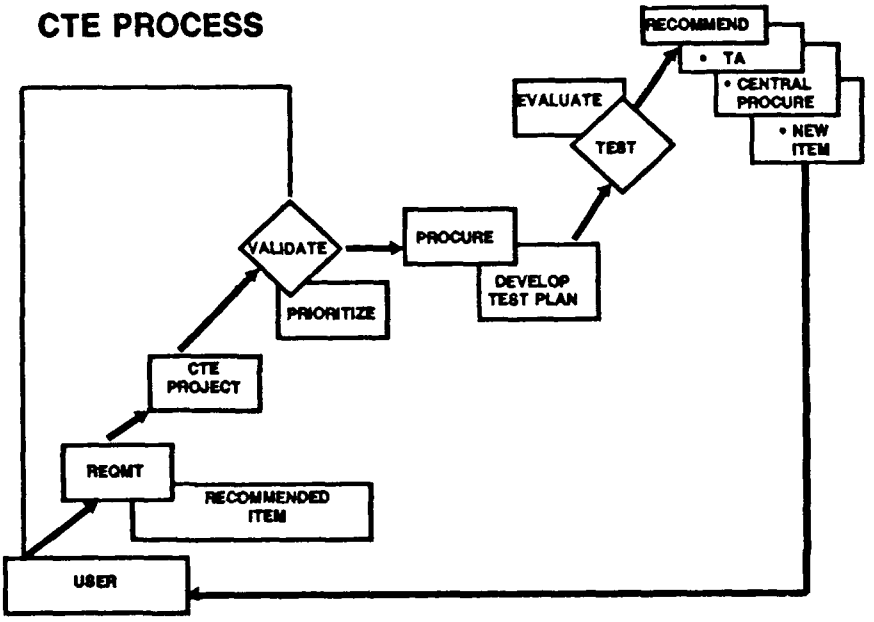
SYNOPSIS

The Air Force Civil Engineering Support Agency has developed a program to keep civil engineering on the cutting edge of technology. The CTE program utilizes databases of sister services and an agency database to meet expanding requirements. The CTE program is an Air Force headquarters-level version of the Applications Engineering Program (AEP) outlined in AFR 93-8. This program enables users or potential users to identify a need for a new piece of equipment (one not presently on the Table of Allowances for that AF specialty) through their agency directorate or Major Air Command to the CTE program manager. If a recommended item source is not available, the agency will scan all available databases or advertise for sources. Both funding and test plan developments may be available for your projects. After the equipment is purchased, it will be tested against the Air Force specification for the requirement. The MAJCOM Directorate or base unit can then use the test results to support addition of this equipment to the Air Force-wide Table of Allowances.

APPLICATIONS

We have already completed tests on well-drilling rigs, chlorofluorocarbon recovery units, juice dispensers, and stock shelving. In a similar manner, we can help you apply the latest commercially available, off-the-shelf technology to meet your mission needs as efficiently as possible.

CTE PROCESS



BENEFIT

Full use of the CTE program by Major Air Commands and bases will eliminate costly research and development of new products by fully exploring the range of viable alternatives that are commercially available.

AVAILABILITY

Our databases contain hundreds of items, ranging from materials available from 3M to modular buildings, well-drilling rigs, and kitchen equipment by Reynolds. A future computer link is programmed to provide easy access to the database for all DOD users, as well as a connection to Joint Service databases, thus providing the broadest possible product listings for all Air Force users.

TECHNOLOGY CONTACT

SMSgt Doug Orlando
HQ AFCESA/RAA
Tyndall AFB, FL 32403-6001
DSN 523-6650

AFCESA TechData are products of HQ AFCESA/RAXI, Tyndall AFB, Fla., 32403-6001.

AIRBASE OPERABILITY

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

FOLDED FIBERGLASS MATS

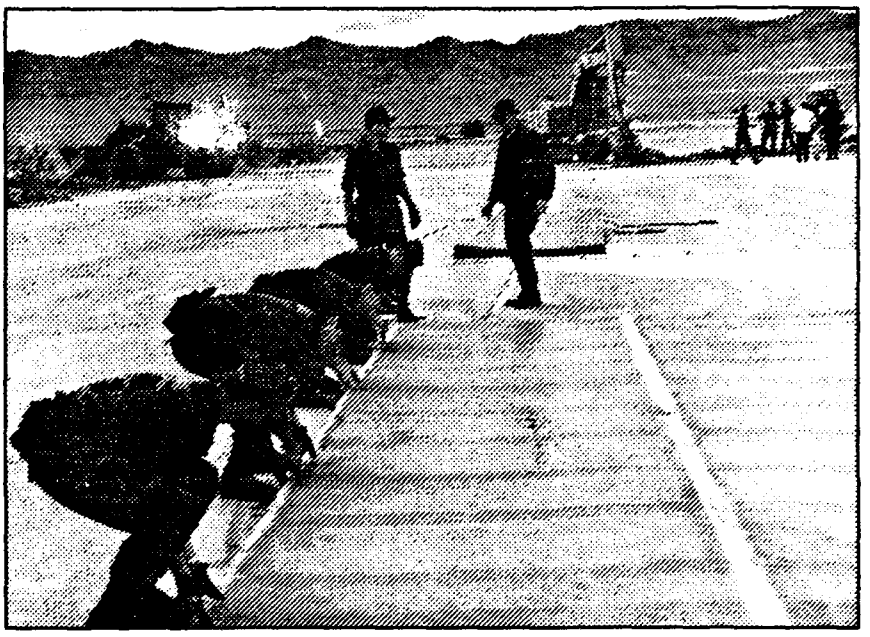
RDC 91-1 **May 1991**

SYNOPSIS:
An air-transportable, easily installed folded fiberglass mat system has been developed, tested, and approved by The Tactical Air Warfare Center for acquisition and delivery to field forces. This mat system represents an improvement in rapid runway repair for forward-operating bases which may come under enemy attack.

Once envisioned as a monolithic mat, manufactured and stored on the airbase, the mat evolved at ESL into a hinged mat which could be folded for shipment and storage.

After initial development by ESL, the mat was turned over to the Engineering and Services Program Office (HQ AFESC/YE) for full-scale development, testing and evaluation. The fiberglass mat system consists of the mats and joining panels; bushing packages to join the mats and anchor them to the pavement; Mat Kit A, which contains all reusable tools to join the mats, install them over the crater, and repair damage; and Mat Kit B, containing the anchor bolts to secure the mats to the pavement.

The folded fiberglass mat system initial operational test and evaluation, conducted at Wendover, Utah, included repair of three craters. The craters were repaired, using fielded RRR systems and procedures developed by HQ AFESC and on-site fill stabilized by geotextiles used below grade. The quality of the repair was monitored, using repair quality criteria developed by HQ AFESC/YER. After vibratory compaction, the mat sections were unfolded, joined into assemblies, and skidded into position over the repairs, using a front-end loader.



Folded fiberglass mats being unfolded and installed.

The mats were anchored to the pavement and trafficked.

Traffic included more than 500 passes — taxi, takeoffs, and full-stop and touch-and-go landings using TAWC F-16 and F-4 aircraft from Eglin AFB.

Also evaluated coincident with the initial operational test and evaluation were:

- A commercially procured, off-the-shelf highway warning sign system, used for distance-to-go marking, which will be centrally procured; and
- A conceptual minimum operating strip marking system utilizing runway edge markers. HQ AFESC/YER will now begin full-scale development of this concept.

APPLICATION:
Each mat is 30 by 54 feet. Normally, two mats are fastened together to cover a 60- by 54-foot area. More than two can be fastened together, depending upon need.

BENEFIT:
These mats represent an improvement over currently fielded aluminum mat repair systems because they are easier to transport, quicker and easier to install, cheaper, safer, more flexible, and more reliable.

AVAILABILITY:
Initial buy of training systems for contingency training sites and Conus home station training sites in March of 1990. Acquisition of opera-

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

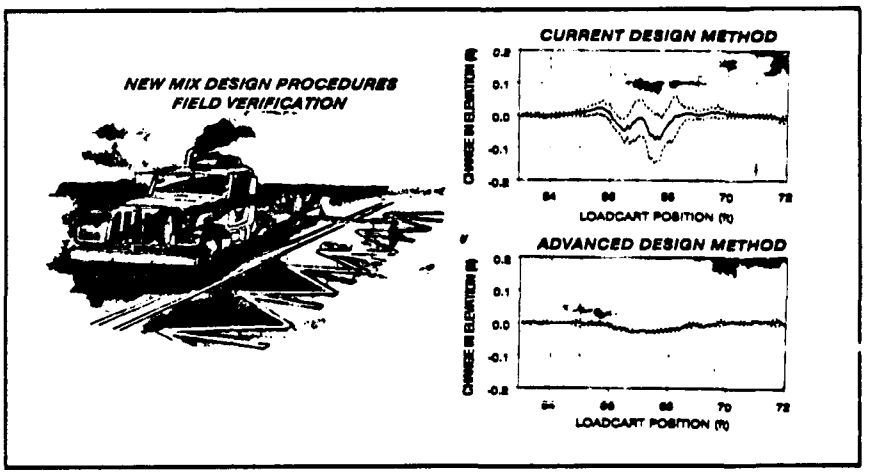
RUT-RESISTANT ASPHALT MIXTURES

RDC 91-2

May 1991

SYNOPSIS:
Recent AFESC testing has shown that the gyratory compaction procedure may represent a very ancient method for designing Air Force pavements able to resist rutting caused by heavier aircraft and increased tire pressures which can go as high as 300 psi. For example, a McDill AFB taxiway had ruts 1 inch deep only 8 months after fielding the F-16D.

In an attempt to address this problem, AFESC completed rutting studies using accelerated trafficking of test sections mixed using both the Marshall Mix and Gyratory Compaction design procedures. Test sections were studied for their response to high tire inflation pressures from F-15 and F-16 aircraft.



Comparison of current and advanced methods.

The key to assuring rut-resistant asphalt mixtures, even under the worst conditions, lies in the laboratory mixing process which must maximize the bitumen content without causing instability. The amount of bitumen selected is mainly a function of the amount of compaction used on the mix in the laboratory. Consequently, design of asphalt mixtures for pavements requires that laboratory compaction be at least equal to that of the traffic. If it is anything less, too much asphalt will be specified and the constructed mat will be too rich. The traffic will further compact the mix. The aggregate matrix will not carry the intended load, which will be transferred to the bitumen, causing the surface to rut.

Our tests have shown that traditional Marshall mix design procedures do not provide sufficient laboratory compaction, and tend to over-asphalt the mix when tire inflation pressures over 200 psi are expected, especially for areas where channelized traffic is anticipated.

On the other hand, gyratory compaction procedures simulate traffic effects on the mix in the laboratory and at the asphalt plant, producing an optimum design binder content for the situation. Further, if the plant produces mix that is out of specification, compacted specimens will pick up the change within 20 minutes; while Marshall procedures require overnight cooling and analysis.

APPLICATION:
This technology is essential for taxiway surfaces expecting high-pressure tire traffic. This gyratory design should be used for all mix designs.

BENEFITS:
The AFESC tests showed that gyratory testing machine procedures produced a mix design that did not rut under 355 psi traffic. Use of this design will produce a surface that can be expected to resist rutting for at least 15 years, decreasing costs and mission disruptions. However, the gyratory mix will be difficult to compact, especially at construction joints, until industry adjusts to the new requirement and until each firm involved in the design of airfield mixtures obtains gyratory compaction machines.

AVAILABILITY:
The AFESC plans to buy an air-transportable gyratory testing machine to help major commands implement these procedures in construction projects. The device can evaluate the product of an asphalt plant in 20 minutes.

DOCUMENTATION:
ASTM D 3387 specifies the gyratory procedures. In constructing the mat, at least 92 percent theoretical maximum density is required, to assure durability and impermeability of mix.

TECHNOLOGY CONTACTS:
James Murfee
HQ AFESC/RDCP
Tyndall AFB, FL 32403-6001

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

JP-8 USE IN HEATING PLANTS

RAC 91-2

December 1991

SYNOPSIS

The concept of supplying a single fuel to the PACAF and USAFE theatres has driven the requirement to evaluate the operational and environmental effects associated with burning JP-8 in boilers. Safe and efficient combustion of JP-8 in heating plant boilers has been demonstrated through small-scale testing at Tyndall AFB and full-scale testing at McClellan AFB. This effort was conducted by AFCESA's Laboratory, Applied Research Associates, Inc, and 325 ABG/DE, McClellan AFB, Cal.

The Air Force boiler inventory provides steam for heating buildings, along with direct support of aircraft maintenance functions, laundries, dining facilities, and hospitals. Installed fire and water tube boilers operate with a variety of burners. Fuel atomization methods include pressure, rotary cup (centrifugal), steam, and air. Primary and secondary boiler fuel supply may be natural gas, diesel, #2 through #6 fuel oils, or coal.

This effort was divided into small-scale testing in a 196,000 Btu/hr Columbia steam water-tube boiler equipped with a Beckett pressure atomizing burner and full-scale testing in a dual-fuel, 25,000 lb/hr Nebraska Boiler Company boiler, fit with a low NOx/low excess air Coen Company, Inc. burner. System performance criteria included the boiler's thermal and combustion efficiencies, heating system thermal capacity, fuel pump performance, overall burner performance, environmentally significant combustion products, the effect of liquid JP-8 on the auxiliary equipment, and effects of JP-8 combustion products on the materials of the combustion chamber. Additional full-scale analyses included flame pattern evaluation, load response, safety control aspects, and boiler operator evaluation.

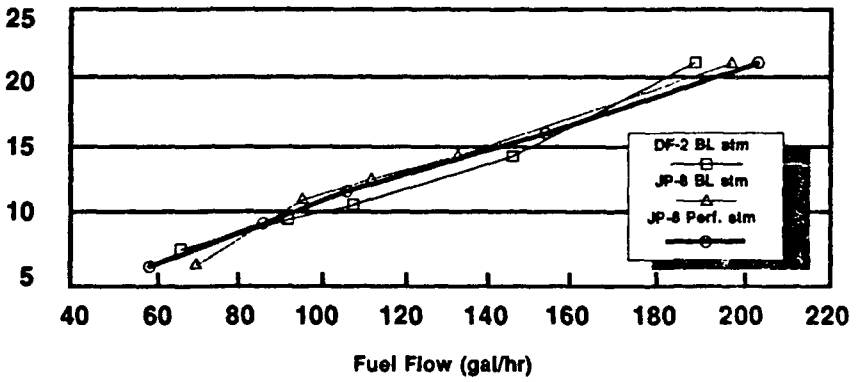


Figure 1. Boiler Performance with Respect to Fuel Flow.

The performance of JP-8 was compared against diesel fuel and #2 fuel oil in the small-scale test and diesel fuel in the full-scale test. JP-8 was burned at the baseline air-to-fuel ratio of the reference fuels before adjusting the settings to optimize its performance.

The results of the small-scale test are summarized in Table 1, with boiler efficiency defined as the ratio of the heat absorbed by the boiler feedwater (boiler capacity) to the thermal energy input associated with the fuel. The excellent performance of JP-8 is attributed to reduced soot buildup on the fireside tubes and better fuel atomization characteristics. Although a 10 percent decrease in boiler capacity is expected because of the lower heating value of JP-8 (126,466 Btu/gal) versus that of #2 fuel oil (140,300 Btu/gal), the system realized only a 5 percent drop in boiler capacity when operating with JP-8.

The performance of JP-8 also fared well in comparison to diesel during the full-scale test.

The boiler was operated under baseline diesel, baseline JP-8, and performance JP-8 conditions. The switch to baseline JP-8 was successfully made, maintaining the same air-to-fuel feed ratios as the diesel operation with no modifications to the system. The third testing condition optimized JP-8 performance with respect to combustion efficiency (measured by stack O2 and CO readings) and the operating

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AIRBASE ENERGY/UTILITY ASSESSMENT

RAC 91-3

December 1991

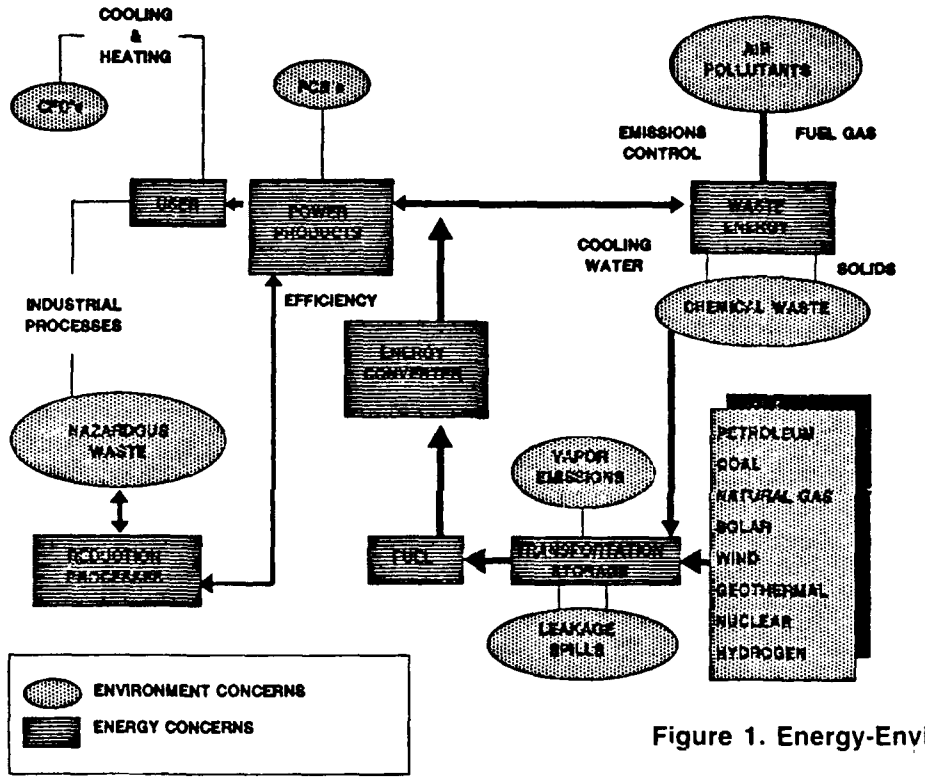

Figure 1. Energy-Environment Link

SYNOPSIS

Air Force airbase energy and utility requirements have been forecast into the next century. This effort results in a recommended AF energy research and development program that will improve the mission, efficiency, and security of civil engineering facilities and utilities through 2020 while considering environmental requirements.

The project identifies the link between energy and environment (Figure 1). The type of environmental compliance or cleanup method chosen will have direct impact on the amount and type of energy consumed. As an example, the replacement of CFCs with HCFCs will reduce the efficiency of the HVAC unit, thus requiring more electricity (more fuel combusted back at the power plant, and more waste heat and emissions). On the other hand, there may be environmental benefits associated with a particular energy method or practice imposed. If waste heat is available through cogeneration or generator exhaust, this heat can be routed through a lithium bromide absorption cooling unit. Cooling can then be provided without the use of CFCs or HCFCs.

The study conducted interviews with each MAJCOM civil engineer, or representative, and his planning, programming, and operations staff. These discussions, along with future system infrastructure requirements gathered from HQs ASD, SSD, and ESD, resulted in an adjusted projection of energy use. This adjusted projection also considers base closures, potential energy shortages, and other external factors. Projected use and costs are shown in Figures 2 and 3.

Discussions with the MAJCOMs indicated that their primary concerns in this area dealt with operating their airbases with reduced O&M funding and rising utility costs (fixed expense), meeting

AIRBASE SURVIVABILITY

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

GEOTECHNICAL CENTRIFUGE

RAC 91-1 **December 1991**

SYNOPSIS

The Air Force Civil Engineering Support Agency (AFCESA) acquired a geotechnical Centrifuge in 1986. Originally used at Kirtland AFB, New Mexico, the centrifuge had been used to test avionics payloads.

The centrifuge is a 15-g-ton capacity testing device. It has a maximum payload of 136 kilograms at a maximum acceleration of 100g's and can carry up to 227 kilograms at 60 g's. The system is powered by a hydraulic drive system. It is housed inside a containment facility 4.9 meters in diameter, 2.1 meters high, with reinforced walls, 0.23 meters thick. The interior walls are painted with an epoxy paint to make the surfaces as smooth as possible, thereby reducing the power consumption and strain on the hydraulic motor. Access to the centrifuge is through the top of the containment facility via hatch doors.

The arms of the centrifuge are 1.83 meters in radius and are integrated with an automatic dynamic balancing system. Limit switches activate automatic shutdown if balance cannot be obtained within the limitations of the self-balancing system. The payload platforms are allowed to swing free on roller bearings, allowing for rotation to the vertical position during testing. If necessary, the platforms can be locked into the horizontal or other intermediate positions.

The centrifuge is operated from a control room separated from the containment facility. Safety switches must be unlocked before operation can begin. Hydraulic

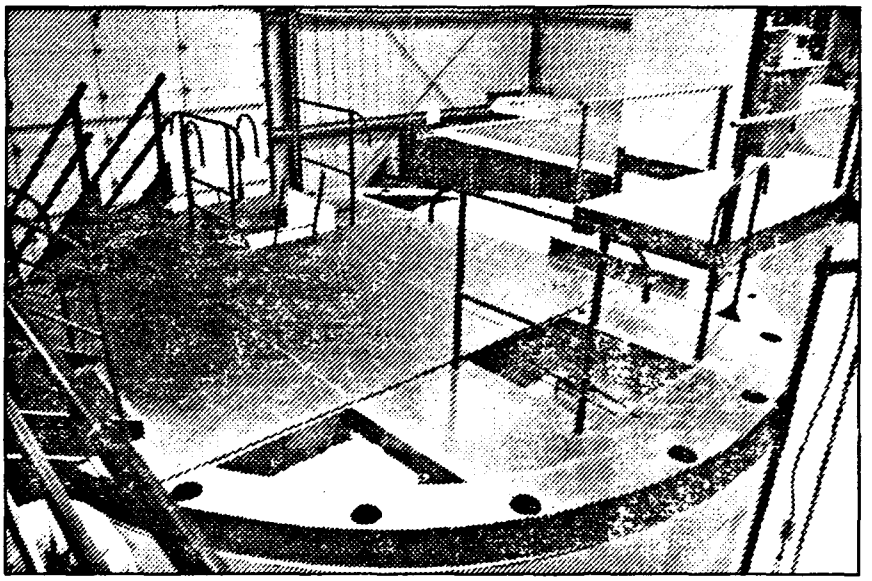

Figure 1. Exterior View of Centrifuge.

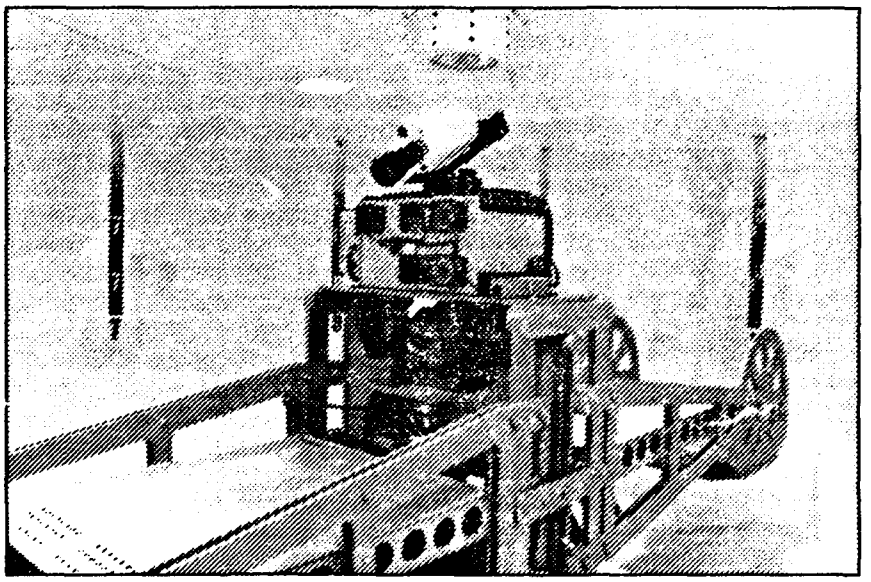

Figure 2. Centrifuge.

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PROTECTIVE CONSTRUCTION DESIGN MANUAL

RDC 91-3 **May 1991**

SYNOPSIS:
AFESC's Airbase Survivability effort has produced a state-of-the-art source book for the analysis and design of structures to resist the effects of conventional/nonnuclear weapons. The 13-Section Protective Construction Design Manual replaces the 1971 Air Force Weapons Laboratory (AFWL) technical report, Protection from Nonnuclear Weapons, which contains many outdated methods.

Since the 1970s, continued advances in nonnuclear areas, have included better analysis of penetration, ground shock, structure-medium interaction (SMI), and shock isolation. These advances and other new technology have been incorporated into this manual. The Air Force Protective Construction Design Manual provides extensive information on conventional weapon effects and design of protective military structures. Numerical examples illustrate how the material pertains to the analysis and design of a protective structure. The manual will serve as a comprehensive source document on the fundamental aspects of protective design for use by engineers whom have basic knowledge in weapons effects, structural dynamics, and hardened protective structures, and who must design survivable facilities.

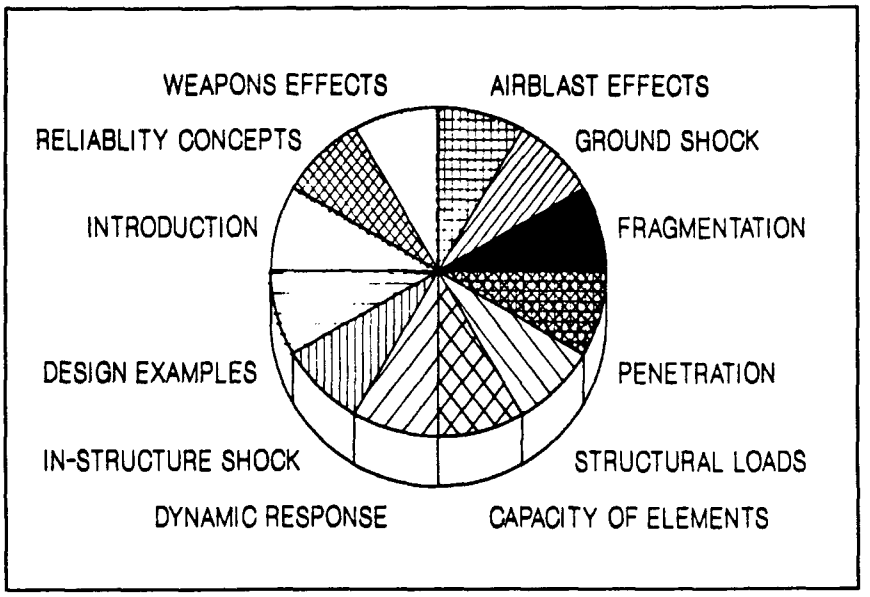
While the manual does not present rules for all design cases and loading conditions, it does provide recommended analysis methods based on state of knowledge as of 1988. This information is augmented by numerous analysis and design references cited throughout the manual.

Design problems are solved in each section to illustrate the application of the specific analysis methods. Four comprehensive examples are then solved in the final section, incorporating all the problems solved throughout the manual. These comprehensive examples are for aboveground and buried concrete box and arch structures. Computer codes are also discussed as they apply to the various analysis methods.

The manual concentrates on the analysis phases (load and response) of the overall design process for protecting structures from conventional weapons. Several checklists are provided for preliminary analysis/design review: interior and exterior weapon effects, common structural elements, and common failure modes of these elements.

Probabilistic design concepts are presented for the first time in an Air Force design document. In following the probabilistic design paths of the American Concrete Institute (ACI) and the American Institute of Steel Construction (AISC). The Air Force is proactively addressing future needs.

The manual addresses problem areas shown in the illustration. An additional section on Expedient Hardening Analysis Methods will be added at a later date.



Summary of design manual coverage.

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MATERIALS FOR EXTERNAL SHOCK MITIGATION

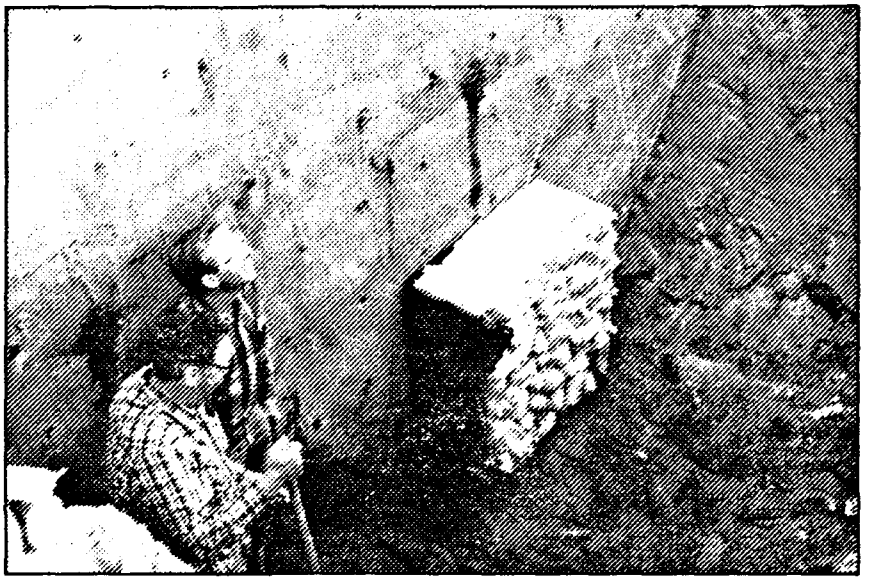
RDC 91-8 **May 1991**

SYNOPSIS:
The Engineering and Services Laboratory has developed and tested two material systems which mitigate the ground shock produced by an earth-penetrating conventional weapon detonated nearby. Both materials significantly reduce both the peak pressure and the impulse transmitted to a buried structure. Both systems use large volumes of entrapped air to isolate a structure from the impinging shock wave.

In explosive field tests at Tyndall AFB, a conventional weapon was detonated near a below-grade wall of a typical hardened protective structure. Two sections of the wall were protected by candidate shock mitigation systems. Pressure gages were placed between the shock-mitigating materials and the structure, and against the wall itself, to record the actual ground shock attenuation.

One section of the shelter wall was protected by a material system consisting of various size Polyethylene Terephthalate (PET) bottles cemented together with a low-density cementitious mortar. This combination of capped plastic bottles and mortar, artificially produces a low-strength material with a random distribution of various size air voids. The resulting composite material system was 52 percent air, by volume. Stress gages revealed that this system transmitted only 10 percent of the peak ground shock stress. The reduction in transmitted impulse was even more impressive. This material attenuated 95 percent of the ground shock impulse.

A second section of the wall was protected by a system of epoxied hollow ceramic beads. The ceramic beads are impermeable to water and crush upon impact, absorbing the ground shock energy. Pressure gages showed that this material Attenuated approximately 90 percent of the peak stress and impulse from the explosion.



Shock-mitigated test panels with plastic soft drink bottles.

APPLICATIONS:
Shock-mitigating materials can be used to enhance the survivability of any buried structure subjected to ground shock.

If applied to the face of concrete bridge abutments and other highway barricades, shock-mitigating materials could serve as impact absorbers. This concept would provide an efficient and inexpensive system of protecting motorists and would be a highly transferable technology.

BENEFITS:
The ability to successfully attenuate ground shock will allow designing more effective and economical protective structures. Also, an effective shock mitigation material offers the greatest potential for hardening facilities already constructed, providing higher survivability and increased capability for sortie generation.

Since PET bottles are not biodegradable, any design concept which utilizes these bottles also provides a more useful means of disposal.

DOCUMENTATION:
The development and testing of these materials is described in a forthcoming ESL Technical Report, *Materials for External Shock Mitigation.*

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AIRBASE FIRE PROTECTION AND CRASH RESCUE

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

SELECTIVE AUTOMATIC FIRE EXTINGUISHER FOR COMPUTERS (SAFECOMP)

RDC-90-1 **November 1990**

SYNOPSIS:

An encapsulated device capable of selective, unsupervised extinguishment of Class A, B, or C combustible materials in Computer-Electronic (C-E) cabinets is now available to protect Air Force high-value computer systems.

SAFECOMP (Selective Automatic Fire Extinguisher for Computers), was developed by AFESC's Engineering and Services Laboratory, in cooperation with the University of New Mexico and the Department of Energy's Oak Ridge National Laboratories.

Development included design, construction, test, and evaluation. The system, designed to extinguish fires at the source and in their incipient stages, incorporates automatic activation of a fire department notification system.

The present systems, using Halon 1301, or depending on total flooding with water, are costly and ineffective because of high installation costs, a requirement for large amounts of halon and water, and extensive damage to computer systems from fire, chemicals, and water.

SAFECOMP consists of four major components, plus a receiver/transmitter that interfaces with the facility supervisory fire alarm system. The SAFECOMP capsule uses a 9-volt lithium battery to operate an ionization smoke detector, a 16-ounce fire agent replaceable cylinder, a squib actuator (pyropneumatic) cartridge and an 85-decibel-below-1-milliwatt audible warning device.

The smoke detector detects the fire, sounds an audible alarm, and causes the actuator cartridge to drive a piston through a metal diaphragm into the pressurized aerosol can of fire agent. The agent is discharged for approximately 10 seconds, permeates the entire cabinet, and suppresses the fire in its incipient state.

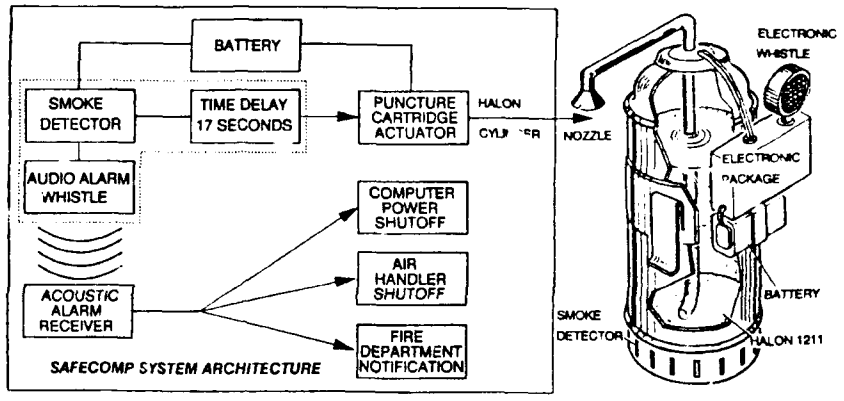

Diagram of SAFECOMP functional elements.

The audible alarm (1) Signals occupants to leave premises; (2) Signals wall-mounted unit to activate transmitter and notify fire department; and (3) Operates control systems to phasedown power and ventilation systems.

The smoke detector enclosed within the computer cabinet lessens the potential for false activation of SAFECOMP by external sources such as smoke or overheating. Moreover, If a false activation occurs, 1 pound of halon is lost to the atmosphere, versus hundreds (or sometimes thousands) of pounds of Halon 1301 with a typical total flood system.

APPLICATIONS:

Will eventually replace total flood halon systems in approximately 90 percent of today's facilities. which need this type of protection for small computer cabinets.

BENEFITS:

This system (1) eliminates damage to computer systems from both prolonged fires and water damage; (2) saves 90 percent of the installation costs; (3) reduces environmental problems caused by releasing large amounts of halon into the surrounding area; (4) reduces cost for protecting Air Force C-E facilities and for providing significant reductions in environmental impact.

AVAILABILITY:

A draft performance specification was given to AFESC's Program Office for review and update. AFSC/DEEF will use this specification to procure units for selected AFSC facilities.

DOCUMENTATION:

ESL Technical Report 83-07, *Selective Automatic Fire Extinguisher For Class A With Notification (SAFECOMP CAN).* Vol. I: Technical Report; and Vol. II: Appendices. ESL Technical Report 86-14, *Selective Automatic Extinguisher For Computer Cabinets Class A, B, or C with Notification (SAFECOMP).*

TECHNOLOGY CONTACTS:

HQ AFESC/RDCF or DEMF, Tyndall AFB FL, 32403-6001; or HQ AFSC/DEEF, Andrews AFB, D.C., 20334.

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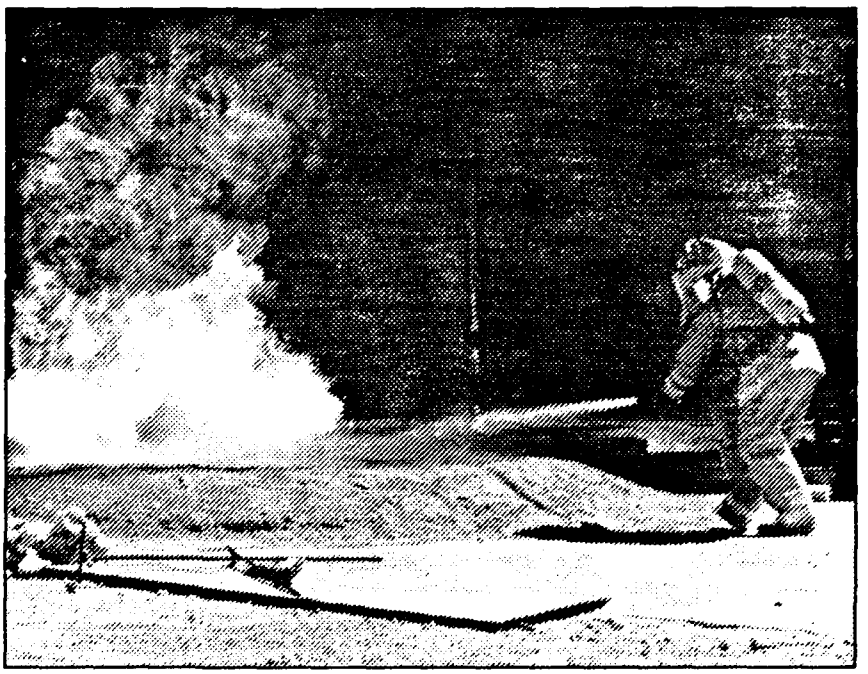
HALON REPLACEMENT AGENT DEVELOPMENT

RDC 91-4 **May 1991**

SYNOPSIS:
We are developing environmentally acceptable, halocarbon agents to replace Halon 1211. An international agreement directs the elimination of Halon use by the year 2000. The production of halons, the most potent ozone-depleting materials being manufactured, will be restricted, starting in 1992, under the terms of the Montreal Protocol. Halocarbons, the most promising family of candidate agents, were selected for further investigation as replacement agents. Candidate agent matrices, database generation methodologies, ozone-depletion potential calculation procedures, and fundamental flame extinguishment data are being used to select and rank materials for evaluation. Methodologies have been established to generate a database of physical, environmental, and toxicological properties of all candidate halogenated agents. This program is also providing computer methods for rapid prediction of ozone-depletion potential from molecular structure and physical properties. Effective experimentation and evaluation methods have been established.

APPLICATIONS:
This technology applies to All Air Force flightline fire extinguishers, and to all Air Force hand fire extinguishers using Halon 1211.

BENEFITS:
This effort will reduce or eliminate use of ozone-depleting firefighting chemicals which threaten the earth's ozone layer. It will also maintain or increase our combat and fire suppression capability.



Application of halon substitute.

AVAILABILITY:
Small-scale laboratory testing is in progress with medium and large-scale testing to follow in the last quarter of FY 91. Toxicity testing will be required to qualify any replacement agent that has not previously been tested and approved. Project completion is anticipated by FY 98.

DOCUMENTATION:
A technical report will be published to provide additional information and documentation.

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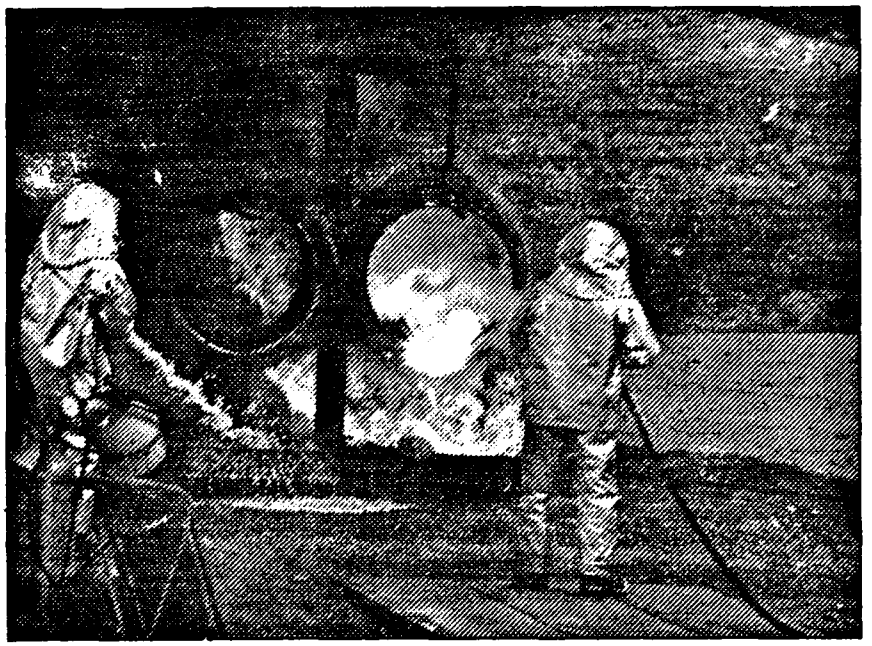
EXTINGUISHING AGENT FOR MAGNESIUM FIRES

RDC 91-6 **May 1991**

SYNOPSIS:
In response to the need for an effective fire-extinguishing agent for metal fires, we have developed an effective firefighting agent for magnesium fires. Modern, responsive, high-speed aircraft should be constructed of strong, lightweight metals, but metals such as magnesium, titanium, and lithium/aluminum, are easily ignited and are difficult to extinguish with standard firefighting agents. Water and carbon dioxide react violently when used on metal fires. A 3-year research program produced a series of highly effective agents known as boralons--blends of an organic boron compound and halon fire-extinguishing agents. The recommended agent was a mixture of 70 percent boron compound and 30 percent Halon 1211. A special delivery system was also developed consisting of a 40-gallon hermetically sealed agent tank with integral-burst disks. When the fire extinguisher is used, the burst disks are ruptured and the boralon is expelled. The program culminated in a successful and repeatable test series extinguishing 200 pounds of magnesium and titanium inside an aircraft engine cowling.



Application of extinguishing agent.

APPLICATIONS:
This technology can effectively supplement Air Force flightline fire extinguishers for metal fire use and serve as a supplement to all hand fire extinguishers where magnesium or other metal fires are expected.

BENEFITS:
The new boralon extinguishers enhance our cababilities to extinguish magnesium fires and provide significant resource cost savings.

AVAILABILITY:
The new boralon extinguishers are being placed at airbases throughout the world. These extinguishers have also been made commercially available for use by the private sector.

DOCUMENTATION:
Documentation is included in ESL technical report, ESL-TR-86-17, *Extinguishing Agent for Magnesium Fires.*

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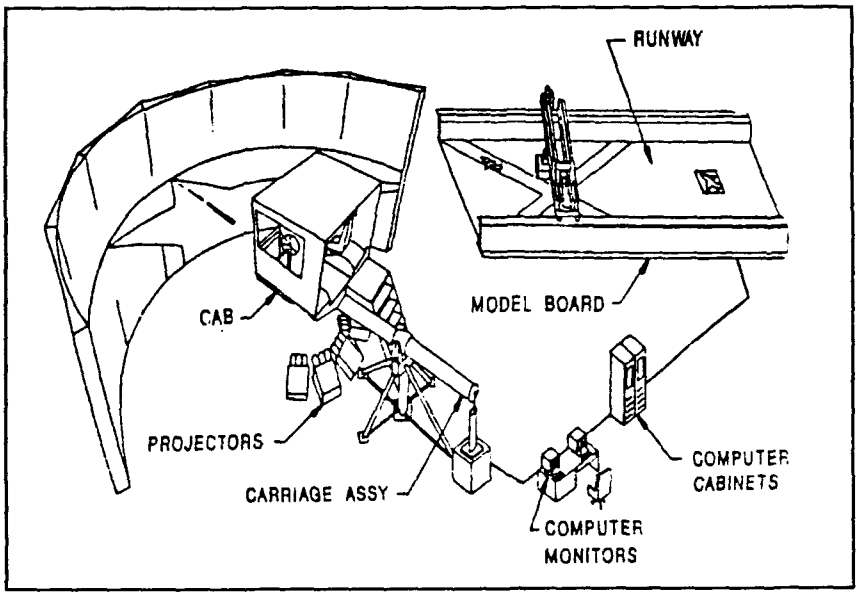
AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

P-4 FIREFIGHTER VEHICLE TRAINING SIMULATOR

RDC 91-7 **May 1991**

SYNOPSIS:
The P-4 Firefighter Vehicle Training Simulator designed, tested, and validated by AFESC will enable USAF Crash/Rescue firefighters to maintain their proficiency despite increasing costs and more stringent environmental constraints. The present live fire training exercises are expensive and cause atmospheric and groundwater pollution. In addition, safety constraints keep these exercises from full duplication of an aircraft crash-fire-rescue operation. These restrictions on live fire training have reduced frequency and created a need for alternative training techniques. This man-in-the-loop trainer for P-4 crash, fire, rescue (CFR) vehicle operators simulates realistic CFR response situations and places real-time demands on operator proficiency and performance. This simulator will alleviate the reduction in live fire training and operator proficiency caused by environmental restrictions. This P-4 operator training simulator uses a full-scale P-4 cab and incorporates two model boards to duplicate realistic firefighting scenarios that include acceleration, braking, noise, and road conditions. The system is housed in a 45- by 8- by 10-foot, 10-ton mobile trailer and includes a self-contained heating, ventilating, and air-conditioning system.



Training simulator system.

APPLICATIONS:
Train all Air Force firefighters in CFR vehicle operations to include turret operations, tactics, decision-making and communications.

BENEFITS:
This system will assure a more proficient Air Force firefighter in CFR operations at decreased training costs, increase combat response capability, and meet stringent environmental requirements.

AVAILABILITY:
Purchase Description and Level III drawings are available for competitive procurement of additional units.

DOCUMENTATION:
Documentation is included in ESL technical reports.

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All MAJCOMS

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ENVIRONMENTAL COMPLIANCE

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

SULFIDE METALS TREATMENT PROCESS FOR HAZARDOUS WASTE MINIMIZATION

RDV 90-2 **November 1990**

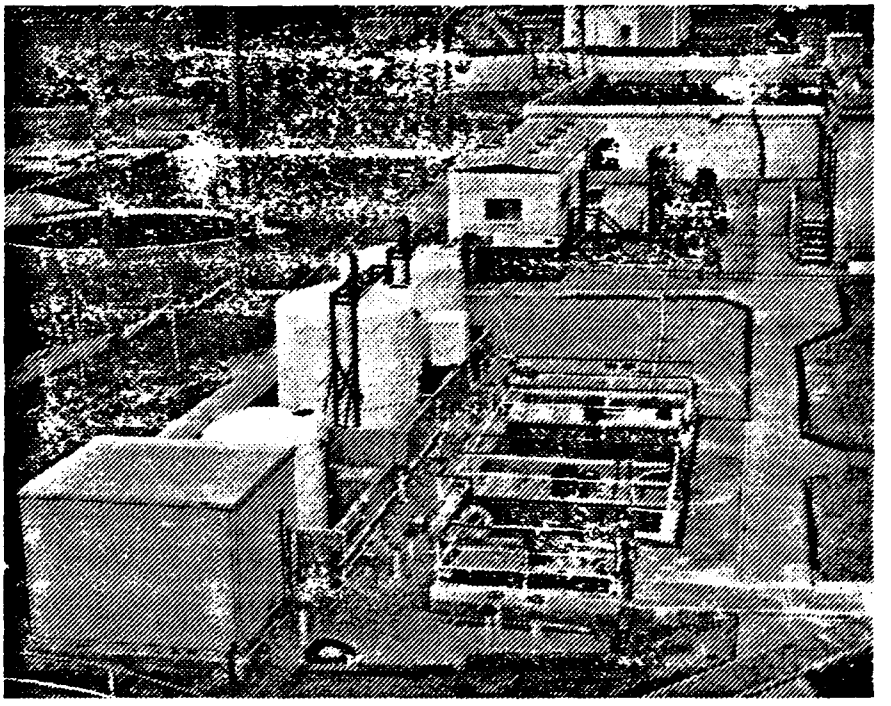
SYNOPSIS:
AFESC's Engineering and Services Laboratory has developed a process change that will minimize the volume of hazardous wastes generated by electroplating operations.

Air Force electroplating facilities generate huge amounts of hazardous wastes that must be disposed of in an approved manner; for example, 8 tons of hazardous sludge per day at Tinker AFB from metals treatment. The principal wastewater contaminants from these processes are chromium, nickel, copper, cadmium, lead, and zinc. Complexing and chelating agents are added to metal finishing solution for brightening, cleaning, and to inhibit or prevent precipitation of the metals. These agents include tartrates, phosphates, ethylenediaminetetraacetic acid (EDTA), and ammonia. These metals and other chemicals are carried into the rinse water, which must be treated at the industrial waste treatment plant (IWTP).

Similar situations exist at the other air logistic centers (ALCs) on five Air Force bases (AFBs). Effluents must meet increasingly stringent limits to comply with the National Pollutant Discharge Elimination (NPDES) Permit system.

These large quantities of sludge, require special handling and costly disposal at approved hazardous waste disposal facilities. These costs are rising continuously. Tinker AFB was paying $168 per ton 1 year ago; they now pay $220 per ton, an increase of over $110,000 per year, and higher costs are expected.

Sludge reduction can decrease these costs to manageable levels. Methods of reducing the sludge include reducing the amount of wastewater, treatment optimization, plating chemical conservation, and sludge dewatering, and, finally, removing the metals from the sludges to produce a nonhazardous product.



Full-scale FeS plant at Tinker AFB, Okla.

These factors have driven a research and development program to explore the use of sodium sulfide and ferrous sulfate to reduce the hexavalent chromium, precipitate the metals, and decrease sludge production and chemical usage. ESL tested and evaluated the process change concept, determined the chemical and physical paramaters for optimization, performed a pilot-scale study to determine full-scale feasibility, evaluated environmental, technical and economical benefits vs conventional treatment systems, and sucessfully conducted a full-scale demonstration at Tinker AFB.

Further studies may bring the process to a point where the effluent quality may match that of ion exchange, but at a much lower purchase and operation and maintenance cost. An effort is also under way to determine the feasibility and economics of recovering the metals from the sludges generated by the Fe/S process. Hazardous sludges left over from treatment by the Fe/S process could be rendered nonhazardous if the heavy metals were removed. Current efforts are directed towards this goal. The work will demonstrate the overall economic impact that could be achieved by reduction of hazardous waste disposal cost and recovery of the strategic alloy ferrochromium and other

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ADVANCED MONITORING EVALUATION DEVICES FOR UNDERGROUND STORAGE TANKS (USTs) AND INSTALLATION RESTORATION PROGRAM (IRP) SITES

RDV 91-1

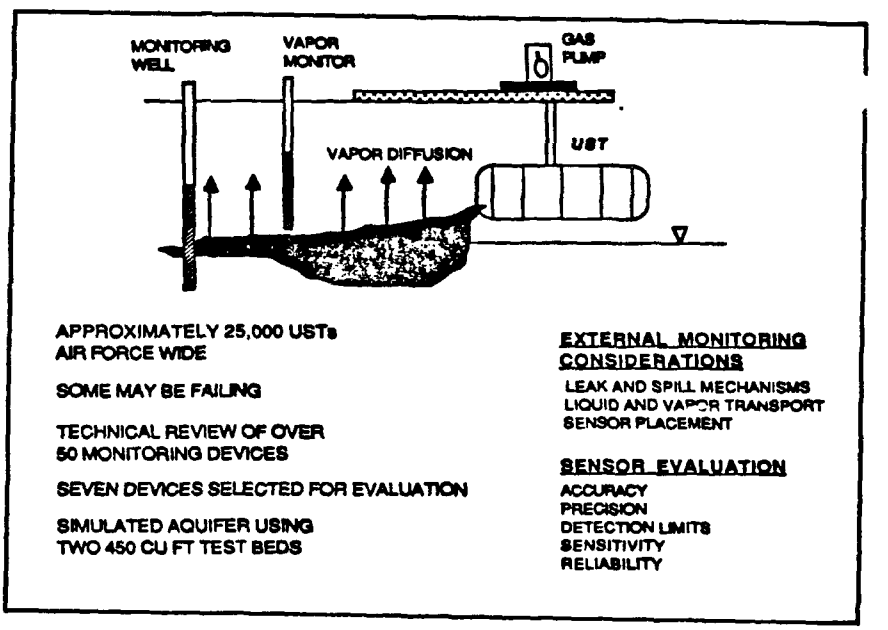
May 1991

SYNOPSIS:

The Installation Restoration Program has intensified the need for increased capabilities to monitor leakage in underground fuel storage tanks. This laboratory evaluated several monitoring devices, representing the available technology for detecting exterior leaks in underground storage tanks (USTs) and for hydrocarbon contaminant monitoring. The devices represented the various technologies available.

Seven devices were tested for both vapor-phase and liquid-phase monitoring. A release that averaged less than 0.02 gal/hr of JP-4 was simulated in sand test beds. Gas chromatography analysis was used to determine actual concentrations. Fresh JP-4 was released into both dry and moist sand to simulate vadose zone monitoring. JP-4 was also released onto a static water table to simulate a leak into the groundwater. Measurement of floating fuel thickness was determined throughout the liquid-phase experiments, as well as liquid and vapor hydrocarbon concentrations. Aged JP-4 recovered from an actual spill site was released and device response recorded. With the aged JP-4 still in the sand, fresh JP-4 was released to determine if the devices can distinguish a new release versus old spill. Devices were tested for false positives in response to interfering chemicals.

The rapid rise in vapor concentration during a leak indicates that vapor-phase monitoring is an excellent method for early warning of product release. Devices using vapor-phase detection for leaking JP-4 had the best overall performance, however they may not be useful in sites with past contamination. Devices monitoring for JP-4 floating product on the water table are not as quick or sensitive as the vapor-phase devices at detecting a leak but they may be useful in sites with residual soil contamination. Hydrogen sulfide, carbon monoxide, and trichloroethylene interfered with vapor phase devices; methane did not. The quantitative output of some devices is a relative measurement; it is not an accurate measurement of the amount of JP-4 in the subsurface. The device output is not linear with increasing concentration; it can be quite variable. Calibration procedures are necessary if the results are to be used for quantitative assessment of contamination.



Setup for testing monitoring devices.

BENEFITS:

Increase capabilities by using more sampling points to provide real-time data. Exterior leak detection can provide an early warning that a leak or spill has occurred from an underground storage tank system so corrective actions can be made, minimizing environmental damage. Use of such devices can provide remote, automated monitoring, decrease costs, and eliminate much manual sampling and laboratory analysis.

AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

THE SUBSTITUTION OF ION VAPOR DEPOSITION OF ALUMINUM FOR CADMIUM ELECTROPLATING

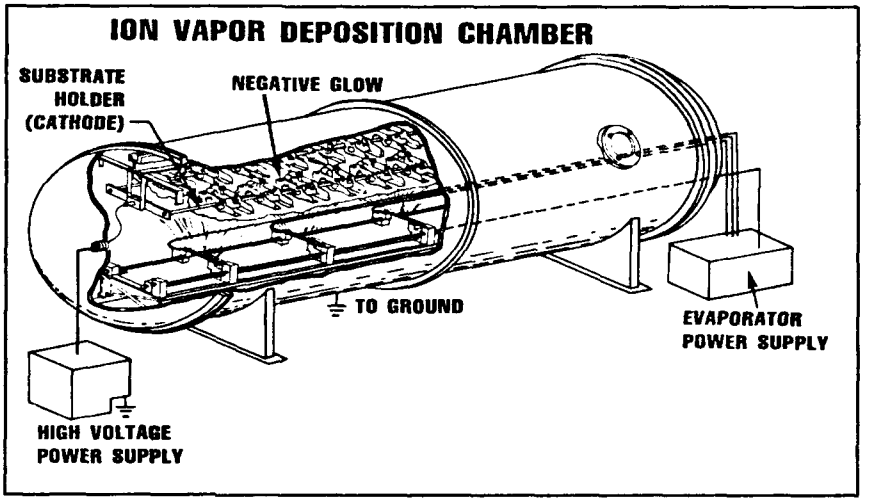
RDV 91-2

May 1991

SYNOPSIS:
The Engineering and Services Laboratory has evaluated an ion vapor deposition technology that can replace the hazardous cadmium electroplating process in Air Force industrial operations.

Cadmium electroplating is used to protect components of weapons systems from corrosion. Cadmium is toxic, and is usually electroplated from a cyanide bath, which is also a very hazardous material, and which, when mixed with acid, releases very toxic hydrogen cyanide gas. About 70 metric tons of cadmium are released to the atmosphere each year from the electroplating process. As more stringent air emission regulations evolve, cadmium and cyanide in rinse waters, atmospheric emissions, and concentrated solutions will require even more expensive treatment and disposal. Cyanide treatment costs Tinker AFB $169,600/yr. This cost, and future liabilities, can be eliminated with the substitution of ion vapor deposition of aluminum for cadmium electroplating.

The IVD aluminum coating is applied in production coating equipment called Ivadizers. The basic equipment consists of a steel chamber, a pumping system, a parts holder, an evaporation source, and a high-voltage power supply (see concept drawing of the IVD coater). The IVD process sequence consists of pumping the vacuum chamber down to about 10-4 Torr. The chamber is then backfilled with argon gas to about 10 micrometers, and a high negative potential is applied between the parts being coated and the evaporation source. The argon gas becomes ionized and creates a glow discharge around the parts. The positively charged gas ions bombard the negatively charged surface of the parts and perform a final cleaning which contributes to good coating adhesion.



Ion vapor deposition chamber.

Following glow discharge cleaning, aluminum wire is evaporated by being continuously fed into resistance-heated crucibles. As the aluminum vapor passes through the glow discharge, a portion of it becomes ionized. This, in addition to collision with the ionized argon gas, accelerates the aluminum vapor toward the part surface, resulting in excellent coating adhesion and uniformity. Both the aluminum coating and the IVD process are environmentally safe.

A database was developed to justify technical order changes in favor of IVD of aluminum; generic and part-specific testing were done as needed, and problem areas were identified. A full-scale system was purchased and installed at WR-ALC, and problem areas were addressed. Demonstration of 'total' elimination of cadmium electroplating at WR-ALC begun in November 1990.

The coating requirements for IVD aluminum are specified in MIL-C-83488. After coating, the parts are generally chromate-treated in accordance with MIL-C-5541. This provides additional protection against corrosion, forms a good base for paint adhesion, and is a common treatment for aluminum alloy surfaces. In virtually all applications, IVD aluminum can replace cadmium of equal thicknesses. It can also be applied thicker than cadmium where par tolerance permits; this results in additional corrosion resistance. A drawback to the system is its size limitation of 5 feet in width. Parts such as the landing carriage for the B-1 bomber would not fit into the production unit. The number of parts that fit into this

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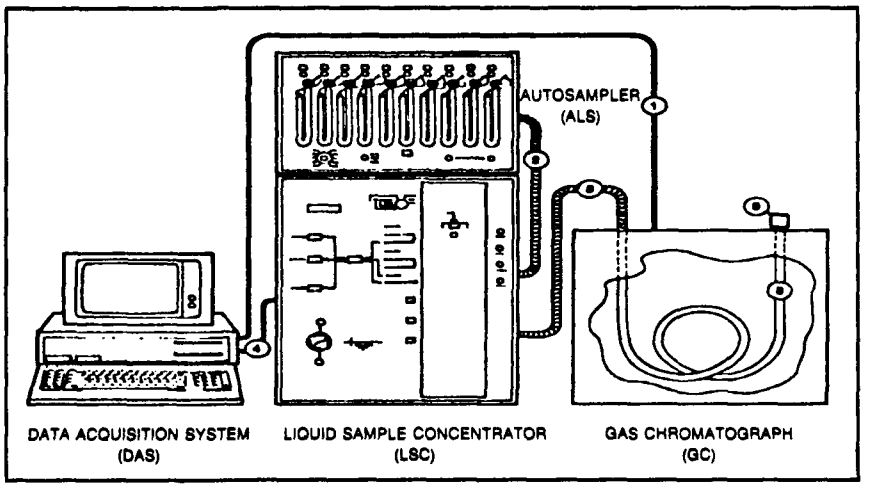
VOLATILE ORGANIC COMPOUND (VOC) MONITOR DEVELOPMENTAL (PHASE 1) PROTOTYPE

RDV 91-3 **May 1991**

SYNOPSIS:
This laboratory has developed, tested, and fielded a Volatile Organic Compound (VOC) monitor that can be used to analyze Trichloroethylene (TCE) in water as required to demonstrate compliance with applicable environmental regulations. This technology provides a turnaround time as short as 1 hour, with routine results achieved on the same day. It also enables the user to program and predict the annual cost of analyses.

Rugged, mature analytical chemical technology (purge-and-trap sample concentration, packed-column gas chromatography, and flame-ionization detection) is automated by a microcomputer that also collects and analyzes data, performs appropriate quality assurance (QA) tests, and delivers a hard copy of analytical results, if QA standards are met. The system is calibrated by delivery of three solutions containing the VOC analyte(s) of interest (TCE) plus internal standards (bromochloromethane, 2-bromo-1-chloropropane, and 1,4-dichlorobutane) at weekly intervals or as required by the QA software. Samples of water to be tested for TCE level are poured into a large syringe; after replacement of the plunger, headspace air and sample in excess of 5.00 mL are expelled. A 50-microliter aliquot of solution containing the three internal standards is added below the surface of the sample, which is then inserted into a Luer-lokT connector feeding into a 40-milliliter sparging vessel. After sample delivery, the valve securing the Luer-lokT port is closed before removal of the syringe. (All sample handling steps must be conducted without exposing the liquids to air bubbles, excessive headspace, or decreased pressure - all of these contribute to lowering measured values.) The unit fielded could store 10 samples for unattended analysis during approximately 6 hours.



Schematic for computer-controlled instrument.

APPLICATIONS:
Can be obtained and used where onsite analysis of TCE in water is needed and where a short turnaround time is essential.

BENEFITS:
This monitor can save both time and money. Unattended operation after sample loading requires approximately 2 hours of manning during each shift that it is in operation. Fixed annual cost to operate is distributed over sample load; break-even point is 10 analyses per week, with virtually no cost to perform additional analyses to system capacity (about 150 a week).

AVAILABILITY:
Fielded measurement of TCE in groundwater (before and after treatment to remove TCE in excess of 1.4 ppm) at Wurtsmith AFB MI. Qualified by U.S. Environmental Protection Agency as local alternate test procedure at Wurtsmith AFB. Items for monitoring system must be requisitioned on an individual basis from respective sources, and local EPA approval must be obtained for its use.

DOCUMENTATION:
Details of development and evaluation, as well as downlisting of software, are found in ESL-TR-88-01, *Prototype Technology for Monitoring Volatile Organics*, Volumes I and II.

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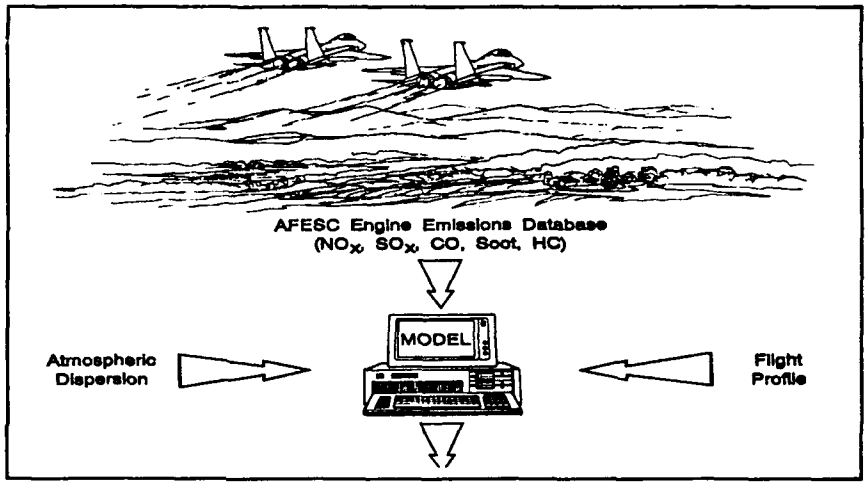
MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE MODEL (MAILS)

RDV 91-4 **May 1991**

SYNOPSIS:
MAILS is a computerized system combining a military aircraft engine emissions database with a simple line source dispersion model. The system estimates pollutant concentration at ground level below flight tracks associated with Military Training Routes (MTRs), Military Operations Areas (MOAs), and Restricted Areas (RAs). The database contains information on expected emissions of carbon monoxide, particulates, and oxides of sulfur and nitrogen for a variety of military aircraft, as well as typical values for aircraft speed. All database information may be modified by the user before being passed to the dispersion model. The dispersion model is a simple Gaussian puff-elevated line source algorithm that requires only aircraft height, flight frequency, averaging period of interest, and height of any existing temperature inversion for input. The model calculates ground-level concentrations for a variety of atmospheric stability and wind-speed conditions, and reports the highest value obtained. Output consists of a listing of input parameters and expected average ground-level pollutant concentrations for selected averaging times. The expected concentration is also expressed as a percentage of allowable National Ambient Air Quality Standards (NAAQS) or Prevention of Significant (PSD) Deterioration increments. The MAILS system is simple and easy to use; whereas, previous manual methods of estimating flight-track emissions and concentrations required the use of a number of tabulated references and a series of manual calculations. The model is somewhat conservatively formulated (assuming wind direction along flight track, choosing largest concentration from matrix of wind/stability combinations, etc), yet demonstrates that aircraft pollution impacts are usually negligible with regard to NAAQS and PSD limits. This should help it gain regulatory acceptance, as well as defend USAF interests in training at low level. The model has not been verified against actual low-altitude aircraft emissions measurements, but has been shown to agree with EPA guideline model results for similar release scenarios.



Emissions model for low-altitude flight operations.

APPLICATIONS:
The model prototype was used in development of the Generic Environmental Impact Statement (GEIS) for low-level flight operations. The final version of MAILS is expected to be used for preparation of the air quality section of Environmental Assessments and Impact Statements concerning MTRs, MOAs, and RAs.

BENEFITS:
Use of this system will Defend USAF ability to train realistically at low-altitude. It should also decrease costs by streamlining and shortening the sometimes lengthy and tedious calculations required to assess air quality impacts of low-level aircraft operations.

AVAILABILITY:
MAILS software will be distributed to MAJCOM/DEVs, AFRCES, and to OEHL Air Quality Branch upon publication of the User's Guide and will also be made available for order through DTIC and NTIS.

DOCUMENTATION:
This technology is documented in ESL-TR-89-59, *MAILS User's Guide* and ESL-TR-90-02, *MAILS Model Development*, to be published by January 1991.

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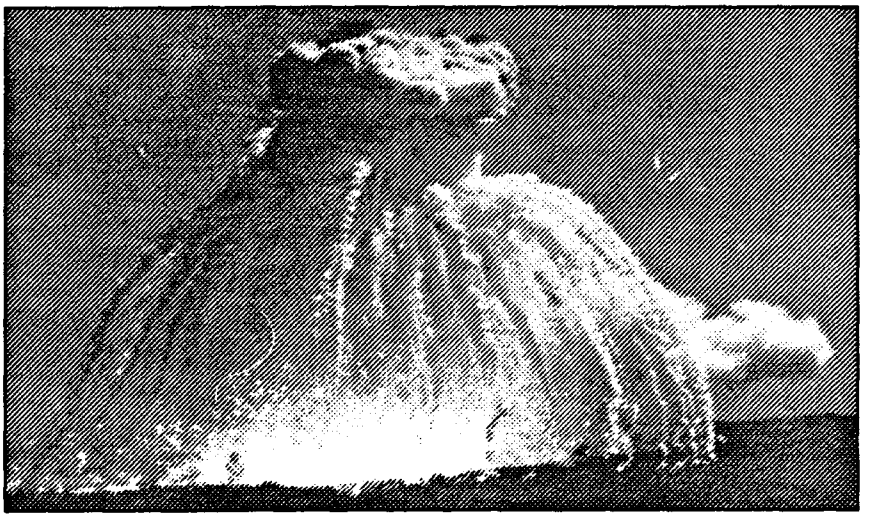
ROCKET EXPLOSION TOXIC CHEMICAL SOURCE STRENGTH MODEL

RDV 91-5 **May 1991**

SYNOPSIS:
Preplanned response to a rocket launch explosion depends on a method to estimate source strengths and calculate the toxic corridor. Source Strength modeling is needed to prevent damage and injury from the actual accident or incident.

A mathematical model was developed which estimates the size, shape, temperature, heat release, and chemical composition of the source cloud resulting from a catastrophic abort of the Titan 34D launch vehicle. The algorithm calculates these parameters as a function of propellant loading, abort altitude and time, and ambient atmospheric temperature and humidity. Equations are based on equilibrium chemical reaction models, radiative transfer relationships, the ideal gas law, and empirical data from missile destruct tests and launch accident case studies. The model applies to the transtage and inertial upper stage configurations of the Titan 34D, and produces a two-cloud source structure. The upper cloud results primarily from hypergolic liquid fuel and ambient air interactions and is dominated by water vapor, carbon dioxide, carbon monoxide, hydrogen, nitrogen, ammonia, nitrogen dioxide, and vaporized hydrazine. The lower cloud is dominated by solid rocket motor combustion products, and consists primarily of carbon monoxide, water vapor, nitrogen, hydrogen, hydrogen chloride, aluminum oxide, and oxygen. The source strength model accounts for the interactions of solid and liquid propellant components with each other and with the ambient atmosphere. Previous model initializations assumed worst-case release of all fuels. Such over-



Titan 34D-9 abort.

conservative application may have resulted in many costly and mission-degrading launch delays (due to hazard corridors overlying uncontrolled populations) as allowable public exposure limits decrease and launch rates increase. Accounting for chemical reactions and buoyant heat release in the source cloud will reduce conservatism, while maintaining safety. The primary drawback of the model is the lack of verifying data. Quantitative chemical measurements of launch accident vapor composition and concentration are rare. Photographic documentation of accidents and empirical missile destruct test results were used to generate engineering assumptions as to propellant mixing ratios, ambient air entrainment, reactivity ratios, and cloud size calculations.

APPLICATIONS:
Model results have been incorporated into the operational Rocket Exhaust Effluent Diffusion Model (REEDM) used by the Western and Eastern Space and Missile Centers to initialize toxic corridor calculations for Titan launch planning.

BENEFITS:
In addition to decreased costs from damage and injuries, scientifically and legally defensible modeling can make USAF less susceptibile to spurious claims and litigation if an accident occurs.

AVAILABILITY:
Algorithms are provided in a recent technical report.

DOCUMENTATION:
This model is described in in ESL-TR-88-35, *Atmospheric Dispersion of Solid and Liquid Rocket Propellants.*

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TECHDATA

REMOVAL OF NOx FROM JET ENGINE TEST CELL EXHAUSTS

EQ 93-2 **April 1993**

SYNOPSIS:
This laboratory has developed an effective reactive sorbent technology to remove oxides of nitrogen (NOx) from combustion exhausts exiting both steady-state and variable sources.

A jet engine test cell (JETC) remains cold until an engine or aircraft is installed for test firing. A typical test firing program comprises a series of short stages, during which engine power progressively increases and temperature, flow rate, and composition of the exhaust vary drastically. At no time during the test sequence does the temperature in the JETC stabilize.

Combustion in gas turbine engines forms visible soot, carbon monoxide (CO), and oxides of nitrogen (NOx) as pollutant byproducts. Soot opacity is regulated, and regulation of other pollutants from JETCs under the Clean Air Act Amendments is pending. Present-generation commercial NOx-control technologies function only within narrow operating windows and offer no control of soot or CO.

Preliminary bench tests in which simulated exhaust streams were passed through a bed of vermiculite or vermiculite coated with any of several amendments, demonstrated removal of 20 to 90 percent of NOx. Efficiency of removal remained fairly constant for flows from 2 to 20 feet per minute and at temperatures from 150 to 300°F. Expanded tests at bench scale identified magnesium oxide (MgO; 1:1) coated on vermiculite as the treatment of choice at temperatures below 300°F and determined that NOx reacts with MgO to form magnesium nitrate. The expected composition of the spent sorbent suggests disposal as a horticultural soil amendment. Analyses of partially used sorbents consistently detected no accumulation of metals.

A series of split-exhaust tests in 906 TFW/AMF's hush house (Wright-Patterson AFB OH) revealed similar removal rates, plus severe vibration and stresses that would destroy control devices placed inside the augmentor tube. With afterburner engaged, stack temperatures did not exceed 200°F.

A complete prototype treatment system was assembled and installed on a test cell run by the 475 WEG/XRM (Tyndall AFB FL). Exhaust from 800- and 1700-pound thrust (subscale drone target) engines was treated with mixed results: Efficiencies of removal remained the same as in earlier tests, but part of the exhaust bypassed the filter through pressure-relief vents. Pressure drop across the 150-square-foot-by-12-inch-thick bed was 1 inch of water. The temperature inside the JETC rose enough to trigger the fire alarms.

Engineering adjustments (an external exhaust blower, more bed surface opening, configuration of the sorbent beds around the air stream) will alleviate back pressure. A representative application to an operational JETC emitting 30 tons/year of NOx is estimated to cost $500,000. Assuming 50 percent removal, $10,000 per year to replace sorbents, and a 10-year lifetime, the unit cost of removal would be $2 per pound of NOx.

OTHER APPLICATIONS:
In addition to its use with Jet Engine Test Cells, this sorbent will also be applicable to such steady-state sources as incinerators, generators, and small engines in hand tools.

BENEFITS:
The technology offers several benefits over existing NOx-control methods: No hazardous materials are used or

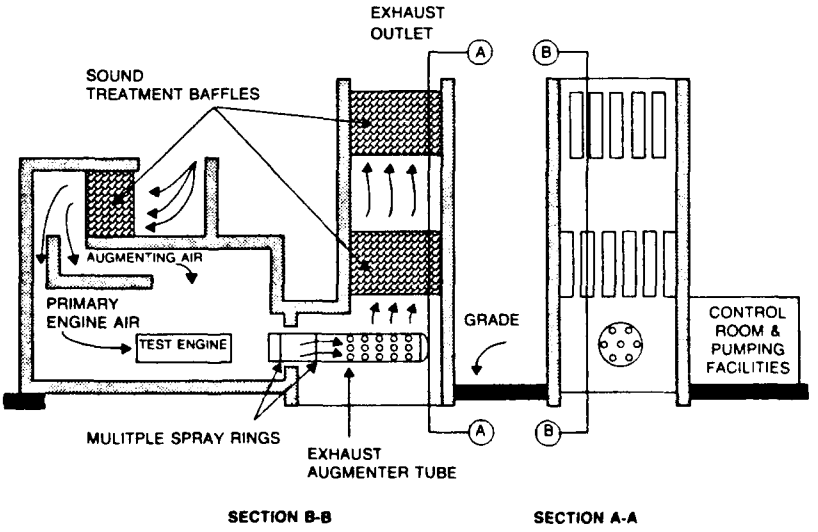

FIGURE 1. SCHEMATIC DIAGRAM OF A TYPICAL TEST CELL.

SITE REMEDIATION

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IN SITU SOIL DECONTAMINATION BY RADIO-FREQUENCY HEATING

RDV 90-1 **November 90**

SYNOPSIS:
This technology can be applied to cleanup of soils contaminated by volatile and semivolatile petroleum and solvents.

Radio-frequency heating is performed by applying electromagnetic energy to the radio-frequency band. The energy is delivered by electrodes placed in holes drilled through the soil. The mechanism of heat generation is similar to that of a microwave oven and does not rely on the thermal properties of the soil matrix.

The power source for the process is a modified radio transmitter. The exact frequency of operation is selected after evaluation of the dielectric properties of the soil matrix and the size of the area requiring treatment.

The gases and vapors formed in the soil matrix can be recovered at the surface or through the electrodes used for the heating process. Condensation and collection of the concentrated vapor stream are used to capture the contaminant above ground.

A field test was performed at the Volk Field Air National Guard Base, Camp Douglas, Wisc. The field test revealed that 94 to 99 percent decontamination of a 500 ft^3 block of soil was achieved during a 12-day treatment period.

The block of soil, measuring 6 feet by 12 feet by 7 feet, was heated to a temperature range of 150 to 160 degrees Celsius. Analysis of numerous pre- and posttest soil samples has indicated that, on the average, 99 percent of the volatile aromatics and aliphatics had been removed from the 500-cubic foot heated volume; 94 percent of semivolatile aliphatics and 99 percent of the semivolatile aromatics were also removed.

Removal of higher boiling point contaminants also occurs from the steam distillation provided by native moisture. The soils at Volk Field are predominantly fine to coarse-grained sandstone with interbedded shale and overlying unconsolidated sand. Soils beneath the fire training area are 95 percent sand with 5 percent by weight finer than sand. Mineralogically, soils are at least 98 percent alpha quartz with no clay as determined by X-ray diffraction.

Cost estimates for the full-scale system for the treatment of soil range from $29 to $60 per ton of contaminated soil.

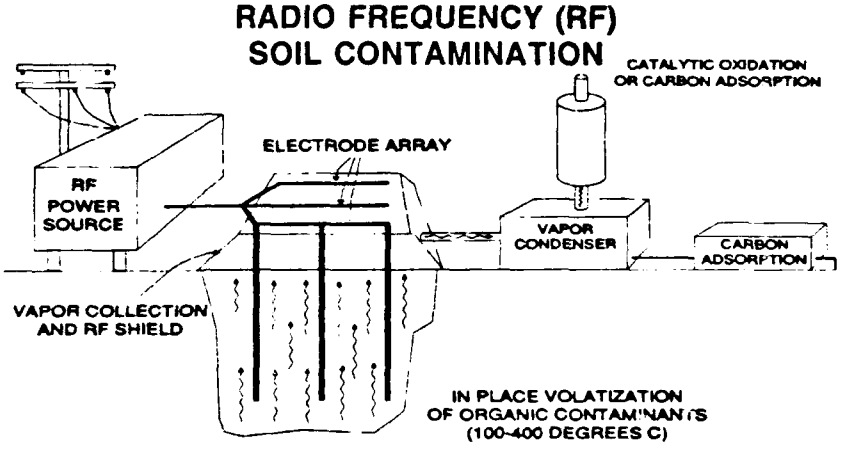

Diagram of RF soil venting.

APPLICATIONS:

Although the first field test proved promising, the process has not been tested at the full-scale level to assure even distribution of heat over a wide area (treating successive modules of 9200 square feet).

RF heating also has not been demonstrated in clay type soils. Both of these areas will be tested in a study in FY 91.

The process minimizes subsurface impact reducing fugitive vapors associated with excavation processes.

BENEFITS:

When developed and approved, this technology can provide a more cost-effective and efficient tool for removing hazardous chemicals from in situ soils and lead to better site remediation.

AVAILABILITY:

The first phase has proven successful for sandy soil in laboratory and scaled down field testing. Plans are underway to conduct full-scale testing at Kelly AFB. When testing is completed and approved, this method will be available.

DOCUMENTATION:

This technology is documented in ESL TR 88-62, *In Situ Soil Decontamination by Radio-Frequency Heating-Field Test,* published September, 1989.

TECHNICAL CONTACT:

Capt. Ed Marchand, HQ AFESC/RDVW, Tyndall AFB FL, 32403-6001, DSN 523-6023

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IN SITU SOIL VENTING FOR SITE REMEDIATION

RD'/ 90-3 **November 1990**

SYNOPSIS:

A promising site remediation technology for JP-4 Trichloroethylene (TCE) and gasoline spill sites nas been developed and pilot-tested at Hill AFB, Utah. *In situ* soil venting is intended to remove volatile and semivolatile organics from contaminated soils in the vadose zone.

Venting wells are placed in the unsaturated zone and connected to a manifold and blower. A vacuum is applied to the manifold, and gases are extracted from the soil and routed to an emissions control treatment system. Because extraction gas concentrations can exceed the explosive limits, explosion-proof blowers might be required.

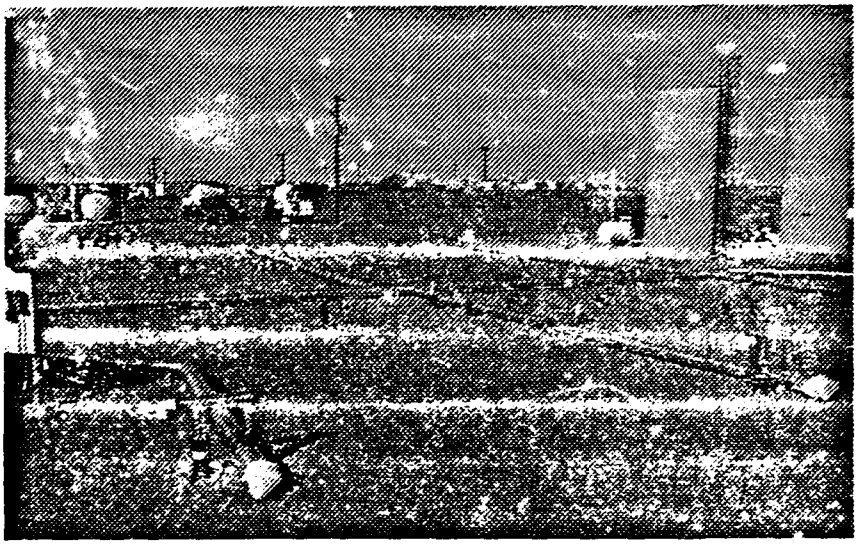
A technology demonstration site at Hill AFB (sandy soils) had the following results for a JP-4 spill site: A system of 16 vents, at an average depth of 50 feet, pulling a total of 1,500 cfm from two blowers, removed 114,906 pounds of hydrocarbon over 10 months.

Results

Total petroleum hydrocarbons in the soils were reduced to an average concentration of less than 100 parts per million.

Catalytic oxidation was used to destroy the venting emissions, achieving an average destruction rate of 95 percent.

Costs for the 1,500 cfm system are $130,000 for design, capital, and installation; and $20,000/year for operations and maintenance. Emissions control costs run about $100,000 (includes rental of the catalytic oxidation unit) and about $13,000 for sampling. The estimated costs for carbon adsorption with off-site regeneration would be about $1,000,000. Total costs were estimated to be $22/cubic yard of contaminated soil.



Full-scale soil-venting demonstration at Hill AFB.

BENEFITS:

The system is good for removing volatile and semivolatile organics from unsaturated porous soils. A single-vent pilot test should be conducted before full-scale implementation.

Venting vapor concentrations drop off exponentially over the life of the remediation effort. Pulsed pumping (shutting off the blowers over night) may be effective, allowing the pores to come to equilibrium before reapplying the vacuum. The long tailering concentration tail indicates that it may require longer times to reach a very low contaminant level. Applying heat (such as exhaust from the catalytic oxidation unit) through additional wells in the plume might increase the removal rate slightly. At contamination depths of less than 10 feet, excavation and onsite treatment could be less expensive.

APPLICATIONS:

Because soil venting increases the subsurface O2 levels, biodegradation plays a large part in the cleanup. The CO2 levels in the vented soil should be monitored to determine the extent of biodegradation at your site. These data are needed to determine total hydrocarbons removed and destroyed.

Pilot-scale testing was completed at Hill AFB; however, since each site is different, each site should have an advance pilot-scale demonstration to determine the optimum full-scale system needed to clean up that particular site. Needed modifications could then be made, based on pilot-scale testing.

DOCUMENTATION:

This process is described in ESL TR-90-21, *In Situ Soil Venting — Hill AFB, Utah,* due for publication.

TECHNICAL CONTACT:

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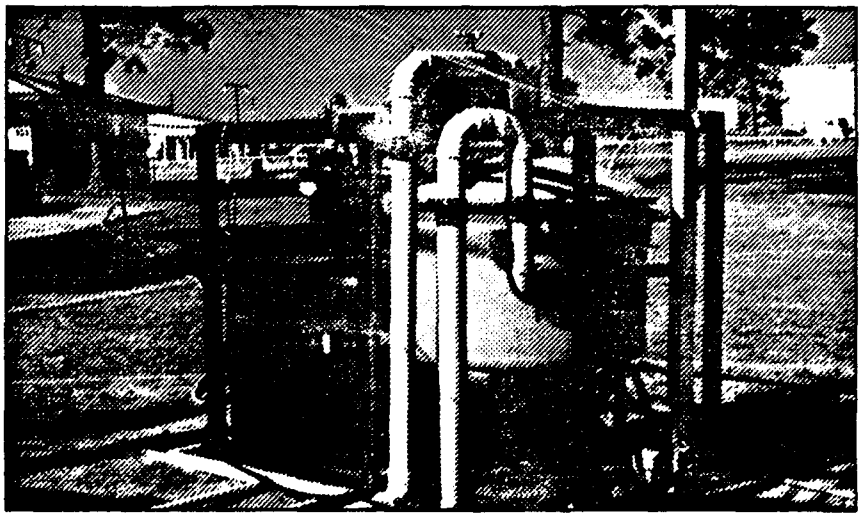
ROTARY AIR STRIPPING (RAS)

RDV 91-6 **May 1991**

SYNOPSIS:
Rotary air stripping is a technology developed to remove volatile organic contaminants from groundwater. The technology has been proven on benzene, toluene, xylenes, trichloroethylene, 1,2, dichloroethane, and tetrachloroethyene. Influent contaminant concentrations ranged from 63 to 19,000 parts per billion. Liquid flow rates ranged from 50 to 120 gpm.

The air-stripping process is designed to bring contaminated water and clean air over the surface of a packing material. The air and water flow countercurrent to each other. In conventional air stripping units the water is pumped to the top of the tower and is moved downward by gravitational forces. The rotary air stripping process uses a rotating packed bed to increase the acceleration or 'g' force imparted on the liquid. The increased g force creates thinner liquid films coating the packing media, increasing the area of contact between the air and water, which, in turn, enhances the overall mass transfer (that is the transfer of the contaminant from the water to the air stream). The mass transfer characteristics of the RAS are improved ten- to fifteenfold, compared with mass transfer characteristics of conventional countercurrent packed-bed columns. The RAS uses a packing material made of a metal foam with a high specific surface area and a correspondingly high porosity.

Generally, removal efficiencies in excess of 99 percent were achieved for all contaminants (except 1,2, dichloroethane) at an air-to-water ratio and rotor speed of 30:1 vol/vol and 435 rpm, respectively. Removal efficiency increased with increasing air-to-water ratio and rotor speed, but was not affected by contaminant concentrations. A 'breakpoint' in the removal efficiency does occur. Above the breakpoint, increases in air/water ratios and rotor speeds cause very little increase in the removal efficiency. The estimated cost for a unit to operate at 99.9 percent removal of benzene from a 90 gpm influent, with the RAS running at 600 scfm air flow and 437 rpm is round to $0.21/1000 gallons water treated.



Cross section, rotary contactor.

APPLICATIONS:
The technology is ideal for low-profile air stripping needs (i.e. near active runways) since the unit has a much smaller packed-bed volume. A typical 50 gpm unit stands only 6 feet tall. In addition, for volatile organics, the amount of air used to strip the organics can be reduced in the rotary air stripper due to the increased mass transfer capabilities.

BENEFITS:
The reduced emissions control requirements could offset the added expense of spinning the rotor and the initial cost for the custom unit. It is hoped that further studies will alleviate the the iron precipitation/fouling problem associated with all air stripping units. Solution of this problem would enhance applicability.

AVAILABILITY:
The unit is commercially available through air stripping vendors and small firms specializing in rotary air stripping.

DOCUMENTATION:
HQ AFESC/ESL TR 86-46, *An Evaluation of Rotary Air Stripping for Removal of Volatile Organics from Groundwater*, published Feb 87 and ESL 90-51, *Air Stripping and Emissions Control Technologies*, to be published in 1991.

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AIR FORCE ENGINEERING AND SERVICES CENTER

TECHDATA

ENHANCED IN SITU BIODEGRADATION OF PETROLEUM HYDROCARBONS THROUGH SOIL VENTING

RDV 91-7 **July 1991**

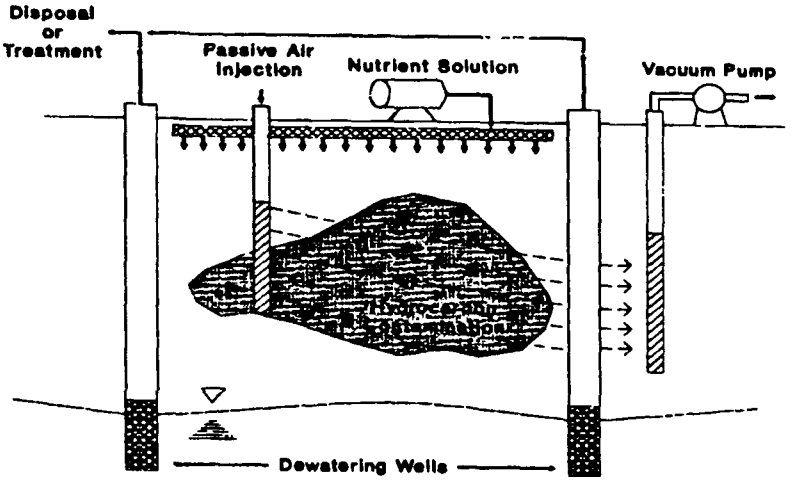
SYNOPSIS

This technology can be applied to the cleanup of unsaturated soils contaminated with petroleum hydrocarbons.

Soil venting is effective for the physical removal of volatile hydrocarbons from unsaturated soils. Vadose zone or unsaturated soils are those which lie above the water table. This technology can also provide oxygen for the biological degradation of hydrocarbons in contaminated soil. Common strains of soil bacteria are capable of biodegrading hydrocarbon contaminants. Treatment of the off-gas from a soil venting system can contribute up to 50 percent of the overall cost of the remediation system. Through the optimization of venting air flow rates, the amount of hydrocarbon removal attributed to *in situ* biodegradation can be greatly increased. This approach may eliminate the need for off-gas treatment, thereby reducing overall site remediation costs.

A pilot-scale field test of bioventing was conducted at a JP-4 jet fuel contamination site at Tyndall AFB. The soil in the area of the spill site consisted of very fine to fine unconsolidated quartz sands with trace occurrences of organic material. Soil hydrocarbon concentrations ranged from 30 to 23,000 mg/kg soil and soil moisture content ranged from 6.5 to 9.8 percent.

Two enclosed plots of contaminated soil (4.9 meters x 1.8 meters x 1.5 meters deep) were constructed. An air venting and a nutrient/moisture delivery system were installed in each plot. The



Plots were operated under varying air flow rates and varying nutrient/moisture conditions for 188 days. Two similar plots were also constructed in uncontaminated soil. One was used to determine the amount of background respiration and the other used to evaluate the potential for biodegradation of hydrocarbon vapors by passing the off-gas from one of the contaminated plots through the uncontaminated soil.

Measured biodegradation rates within the soil cells ranged from 2 to 20 mg/kg/day. Nutrient and moisture addition had no significant effect on biodegradation rate. Biodegradation rate constants were affected by soil temperature and followed the predicted values based on the van't Hoff-Arrhenius equation. The amount of hydrocarbon removal attributed to *in situ* biodegradation could be increased to 85 percent by management of the venting air flow rate.

When contaminated off-gas was passed through a plot of clean soil the contaminants in the airstream were biodegraded by the naturally occuring microorganisms. Results from pre- and post-sampling of soil showed that the contaminants were not removed by sorption onto the soil particles. Based on the data collected at this site, a soil volume ratio of approximately 4 to 1, uncontaminated to contaminated soil, would be required to biodegrade the off-gas from a similarly operated bioventing system.

Cost estimates for an operational bioventing treatment system range from $12 to $15 per cubic yard of soil, assuming no treatment of the off-gas emissions will be required.

E&S TechData sheets are products of HQ AFESC/RDXI, Tyndall AFB, Fla., 32403-6001.

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

PC-BASED PROGRAM FOR AIR-STRIPPER DESIGN AND COSTING (ASDC)

RAV 92-1 **February 1992**

SYNOPSIS:

Packed-tower, countercurrent air stripping is being employed with increasing frequency for removal of volatile organic compounds (VOCs) from contaminated water. Several studies have shown that air stripping, even with off-gas treatment, can be cost-effective for removal of VOCs from water.

Design of an air-stripping unit is performed using a well-developed mathematical model of the process, based on principles of mass transfer. Because the number of variables involved exceeds the number of constraining equations, a variety of air stripper designs can be employed. Each unit can meet certain removal requirements, but can have drastic differences in operating and maintenance costs.

A user-friendly PC-based program to design air strippers has been created to ensure selection of the optimum unit.

APPLICATIONS:

The menu-driven program, written in C language, contains databases on costs and chemical characteristics. It also contains other pertinent information needed to design an optimum air stripper. The databases include 114 common contaminants and 57 variations of packing material. The databases can be expanded with a system-prompted internal program.

The cost model incorporated in ASDC enables comparison of approximate costs for different designs. Major capital and operation costs are evaluated for each design by summing individual component capital and operating costs. Features that enable modification of some cost factors (for example, packing material unit cost, electricity rate) and adjustment for inflation are included in the program. Up to 144 separate designs can be run simultaneously.

The various components of ASDC, as well as the entire program, have been tested to verify that the software correctly represents the design and cost models employed. Tests for some critical subroutines in the program such as the variation of Henry's Law constant with temperature are outlined in the report. In addition, ASDC predictions of air-stripper performance and cost are compared to performance and cost data for some actual air-stripping units in the last section of the report.

DOCUMENTATION:

The technical report, which also serves as a user guide to the program, is ESL TR 91-40, Air Stripper Design and Costing: A Microcomputer-Based Program for Air Stripper Design and Costing, due for publication in April 1992. A copy of the software is available at nominal copying cost from:

Dr David Dzombak
Department of Civil Engineering
Carnegie Mellon University
Pittsburgh PA 15213-3890

Government agencies can obtain copies at no charge from:

Chemical/Physical Treatment
Technology Area Manager
HQ AFCESA/RAVW
Tyndall AFB FL 32403

(Include two double-density diskettes with your request.)

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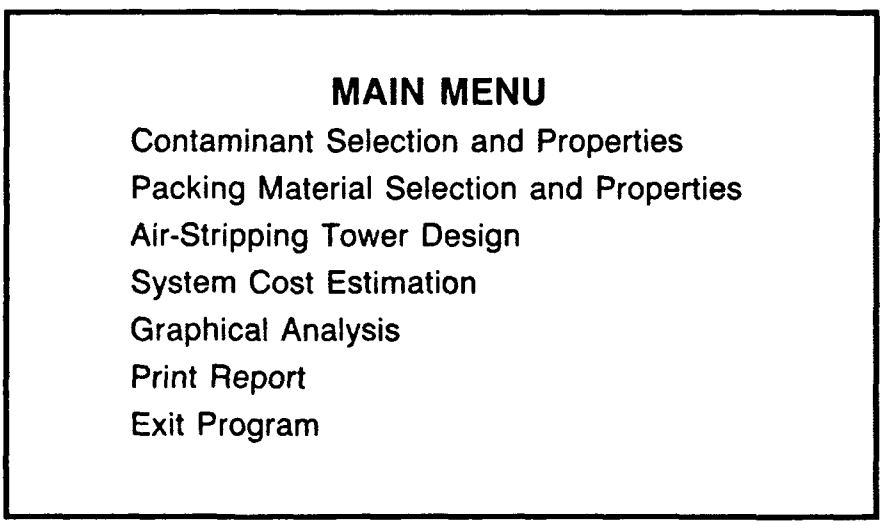


ASDC Main Menu

AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

IN SITU SOILS WASHING

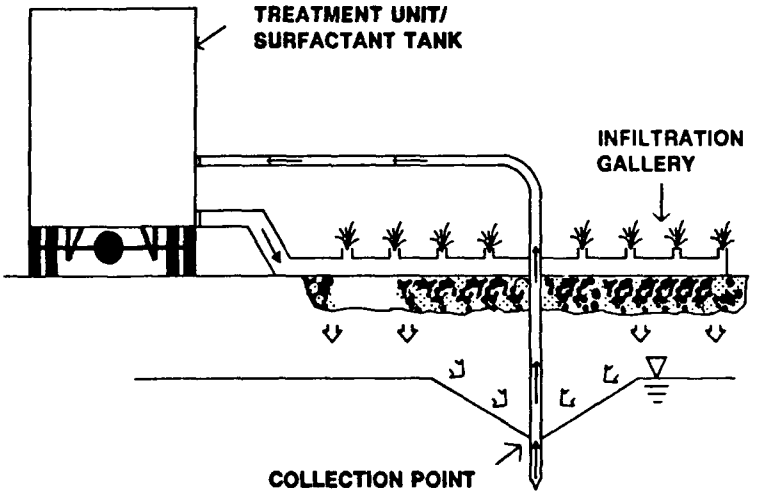
RAV 92-2 **August 1992**

SYNOPSIS:

In situ Soils Washing is a technology that can be applied to the site restoration program in cleanup of petroleum- and solvent-contaminated soils.

A series of seven test areas was established in the fire training pit at Volk Field Air National Guard Base, WI, to determine the soil-washing abilities of a number of surfactant solutions. The wash solutions (S1-a mixture of ethoxylated fatty acids, S2-an ethoxylated alkyl phenol, and S3-an anionic sulfonated alkyl ester) were applied at concentrations from 0.025 percent to 1.5 percent at a rate of 3 inches per day (based on percolation rates). A decrease in percolation was observed in most of the test areas. The 14-pore volume target was reached in only three test cells. Following the surfactant wash, the test areas were rinsed with clean, upgradient well water.

Despite the repeated success of engineered surfactants to clean contaminated soils in laboratory column tests, no data were obtained in the Volk Field test to statistically confirm *in situ* soils washing as a viable method of soil decontamination. If soil cleaning did occur, it was much less than the 75-94 percent achieved in laboratory column tests. Repeated washings of soils with several surfactant solutions actually led to a noticeable reduction in soil permeability. This clogging



effect had two potential causes: surfactant micell formation in the pore spaces, or a surfactant-enhanced movement of fine particles into the soil structure until they filled in the pore spaces deeper in the soil. Neither of these theories has been confirmed. Although the laboratory columns were packed to simulate *in situ* conditions, the noticeable reduction in soil permeability was not predicted in the laboratory. This underscores the importance of small pilot-scale testing on all contaminated sites before full-scale design of decontamination technologies.

APPLICATIONS:

Even though the soil type at Volk Field is described as Boone fine sand, the technology of *in situ* soils washing did not statistically reduce the hydrocarbon concentrations in the subsurface. This technology is not acceptable for use and is not recommended at this time. Above ground soils washing (excavation and processing the soils above ground) was not addressed.

DOCUMENTATION:

HQ AFESC/ESL TR 87-18, *Surfactant-Enhanced In Situ Soils Washing*, published Sep 87.

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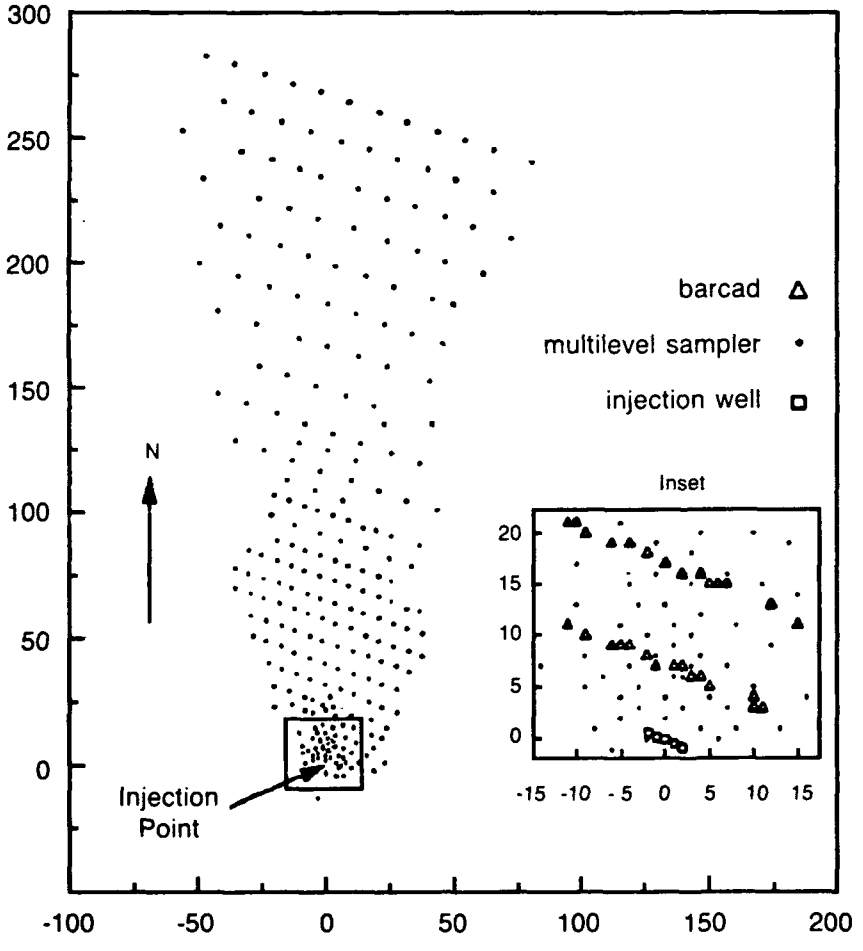
AIR FORCE CIVIL ENGINEERING SUPPORT AGENCY

TECHDATA

GROUNDWATER CONTAMINANT TRANSPORT DATABASE

EQ 93-1 **April 1993**



Sampling Sites

SYNOPSIS:

Groundwater contamination by JP-4 chemical components is a problem at many Air Force hazardous waste sites. Complete contaminant transport data sets from actual field sites are limited, especially in neterogeneous systems. This lack of adequate field data prevents testing of existing groundwater transport models and inhibits development of more accurate models. An injection of known quantities of jet fuel chemical components occurred at Columbus AFB, MS in June 1990 and is known as the MAcroDispersion Experiment (MADE). The chemicals were injected into the heterogeneous aquifer and the resulting plume was sampled as it moved throughout the test site. The site covered 25 acres and contained over 300 multilevel sampling wells. A major technical finding as well as tangible product came from this work. The most significant technical finding was that the injected hydrocarbons were naturally biodegraded over the course of the experiment and they never exited the sampling well network. The tangible product from the study is a data set providing x,y,z, locations of the hydrocarbons and their concentrations as a function of time.

APPLICATIONS:

The data set containing the spatial distributions of the contaminant plume at various times is available on high-density computer diskettes. This data set can be used for testing different groundwater transport models or in developing new three dimensional models. (Include three high-density 3.25" diskettes with your request.) Quantification of the *in-situ* biodegradation rates for the jet fuel components may provide a basis for a "no required treatment option" for spilled fuels, also

SECTION III

LABORATORY CONTACTS FOR EACH TECHDATAT AREA

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